A COMMERCIAL GROVE OF BLACK BAMBOO (PHYLLOSTACHYS NIGRA), NEAR KYOTO, JAPAN.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN No. 43.

B. T. GALLOWAY, ~~Chief of Bureau~~.

JAPANESE BAMBOOS

AND THEIR INTRODUCTION INTO AMERICA.

BY

DAVID G. FAIRCHILD, Agricultural Explorer.

SEED AND PLANT INTRODUCTION AND DISTRIBUTION.

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BUREAU OF PLANT INDUSTRY.

BEVERLY T. GALLOWAY, *Chief of Bureau.*

SEED AND PLANT INTRODUCTION AND DISTRIBUTION.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., May 16, 1903.

SIR: I have the honor to transmit herewith a paper entitled "Japanese Bamboos and Their Introduction into America," and respectfully recommend that it be published as Bulletin No. 43 of the series of this Bureau.

This paper was prepared by Mr. David G. Fairchild, Agricultural Explorer, who has been detailed by you to accompany Mr. Barbour Lathrop on his expeditions in search of valuable seeds and plants, and it has been submitted by the Botanist in Charge of Seed and Plant Introduction and Distribution with a view to publication.

The illustrations which accompany this paper, consisting of eight half-tone plates, are considered essential to a full understanding of the text.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

The bamboo has long been known as one of the best of ornamentals wherever the climate is sufficiently mild to permit of its cultivation, but besides its value as an ornamental the bamboo has in its native home a multitude of uses which make it one of the most important plants in the economy of Japanese life.

Both Mr. Barbour Lathrop and Mr. Fairchild are convinced that the bamboo may be adapted to many uses in America, and the present bulletin is intended to call attention to the possibilities in this direction and to describe some of the most important species.

A. J. PIETERS,
Botanist in Charge.

OFFICE OF BOTANIST IN CHARGE OF
SEED AND PLANT INTRODUCTION AND DISTRIBUTION.
Washington, D. C., May 8, 1903.

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JAPANESE BAMBOOS AND THEIR INTRODUCTION INTO AMERICA.

INTRODUCTION.

This bulletin represents a small part of the work accomplished by Mr. Barbour Lathrop's third expedition in search of valuable seeds and plants, and comprises material gathered during a four months' stay in Japan.

Its object is to call the attention of American cultivators to a group of the most beautiful and useful of all plants which has hitherto been neglected by them, either because they believe it adapted only to a tropical climate or to be of only ornamental value, and to point out how far both of these views are fallacious.

Anyone who has attempted to collect data in an Oriental country will appreciate the difficulties which are encountered in working through an interpreter, and will understand that some of the statements in this bulletin must depend upon the accuracy of the translations. Mr. K. Yendo, of the botanic gardens in Tokyo, was, however, particularly well fitted to interpret on botanical matters, and it is hoped few errors have been made.

The writer wishes to express his indebtedness and gratitude for assistance to Mr. T. Makino, of the Tokyo Botanic Gardens, who is the Japanese authority on bamboos; Mr. Isuke Tsuboi, of Kusafuka, near Ogaki, who is one of the best amateur cultivators of these plants; and especially to Mr. H. Suzuki, of Yokohama, for most valuable advice and assistance regarding transplanting and shipping. The valuable work of Sir Ernest Satow on "The Cultivation of Bamboos in Japan," in Volume XXVII of the Transactions of the Asiatic Society of Japan (1899), and above all, "The Bamboo Garden," by Mr. Freeman Mitford (1896), which is the most attractive and useful book ever written on this group of plants, have been drawn upon largely, especially in the preparation of the descriptions of the various species.

GENERAL CONSIDERATIONS.

The bamboo groves of Japan are not only one of the most striking features of its landscapes but one of its most profitable plant cultures.

The largest well-kept groves in the world, except perhaps those of Burma, are growing in the central provinces, and some of these are several square miles in area. In the Tropics generally the bamboo is cultivated in small clumps, but in Japan it is grown with almost the same care that is given to the field crops.

No other nation has found so many artistic uses for the plant as the Japanese, and in no other country, except it be China, is such a variety of forms employed by the common people.

The plant is a necessity to the Japanese peasant; it forms one of the favorite themes of the Japanese artist, and out of it are manufactured some of the most delicate works of Japanese art. The bamboo is in fact one of the greatest cultivated plants of this plant-loving race.

It is a popular misconception that bamboos grow only in the Tropics. Japan is a land of bamboos, and yet where these plants grow it is not so warm in winter as it is in California. In regions where the snows are so heavy that they often break down the young stems and where the thermometer drops to 15° (F.) below the freezing point, the largest of the Japanese species grows and forms large groves.

For many years the gardens of France and England have been beautified by clumps of these Japanese bamboos, and even in America occasional plants can be found growing in the open air, which prove the possibility of acclimatizing these representatives of this most useful family of plants. A temperature of 6° F. has not proved fatal to a large number of the hardy kinds in England.

Although nearly every description of those regions where bamboos grow gives some account of their uses, there is still in the minds of many Americans a doubt as to the value of these plants for growth in the United States.

Bamboos are not like new grains or fodders which will yield prompt returns in money, but they are essentially wood-producing plants, whose timber is unlike that of any temperate-zone forest trees, and is suitable for the manufacture of a multitude of articles for which our own woods are not well adapted. They are the most convenient plants in the world for cultivation about a farmhouse, and in those regions where they can grow would, if introduced, prove themselves in time one of the greatest additions imaginable to the plants of the common people.

The Japanese and Chinese, who are the most practical agriculturists in the world, have for centuries depended upon the bamboo as one of their most useful cultures, and the natives of tropical India and the Malay Archipelago would be much more at a loss without it than the

merican farmer without the white pine, for they are not only dependent upon it for their building material, but make their ropes, mats, tchen utensils, and innumerable other articles out of it, and at the me time consider it among the most nutritious of their vegetables. o enumerate the uses of such a family of plants as this would be like ving a list of the articles made from American pine, and it would ot serve the purpose of this bulletin so well as to simply point out e fact that the wood of this bamboo is suited to the manufacture of different class of articles and fills a different want from that of any f our American woods. Every country schoolboy is aware of the periority of a bamboo fishing pole over any other. Its flexibility, ghtness, and strength distinguish it sharply from any American poles, d make it better suited for a fishing rod than one made from any ood grown in this country. It is because the American schoolboys e so firmly convinced that the bamboo fishing poles are the best that e importers are warranted in shipping into the United States from pan every year several millions of them.[a]

The thin, flexible ribs of the imported Japanese fan are made from e wood of the same plant, and no one can fail to recognize the pecul r fitness of the material for this particular use.

These are two uses of bamboo wood which illustrate its character, d must be familiar to nearly everyone. When one realizes, howver, that they are selected from over a hundred, which would be just familiar to the Chinese or Japanese, it seems highly probable that is wood must be applicable to many other needs among Americans, ich a closer acquaintance with it would reveal. Santos Dumont s employed bamboo extensively in the framework of his dirigible lloons, and Edison once used it in his incandescent lamps.

Americans see in America only the imported poles or manufactured icles as a rule, and from these it is very difficult to imagine the ltitude of uses to which the green, uncured stems are put. It is just such things as can be made quickly from the green shoots that plant is peculiarly fitted, and this suitability for making all sorts handy contrivances is one of the principal reasons why it should be de a common plant among the farmers of those parts of our coun where it will grow.

The bamboos belong to the family of the grasses, and if this fact is pt in mind many peculiarities of their habits and characters will be ily understood. They should be distinguished, however, from the ds, of which we have a number in America, especially such as are led "bamboo reed" or "Arundo" (*Arundo donax*), a rank-growing ss, with stems bearing long broad leaves to their very bases.

[a] The writer was informed by a large grower near Kyoto that 10,000,000 are orted from Japan every year, and that the largest share of them goes to America.

These reeds, although useful, have very soft stems, which are entirely different in texture from those of the true bamboo. The canebrakes of the South are made up of a species of bamboo, but unfortunately the wood of this species is of very little value. The tall, plume-like stem of the bamboo, which sometimes reaches a height of 100 feet, has many of the characteristics of a giant grass (Pl. I). It is composed of joints, is hollow (Pl. VIII, fig. 1), and grows to its full height from a creeping underground stem in a few days, quite as does a shoot of quack grass. The rapidity with which a new culm grows is one of the most remarkable facts about it, and often bewilders the layman, who is accustomed to judge the age of a tree by its size (Pl. VII). Over a foot a day is not an unusual rate during the most rapid growth—a rate of 3 feet per day has been recorded—and a shoot more than 20 feet high may be less than fifty days above the ground. Its development may be compared in a rough way to that of a shoot of asparagus, and anyone who has seen how easily a young stem of bamboo can be snapped off by merely shaking it will appreciate this comparison.

In common with the stems of grasses, those of the bamboo have a hard, siliceous exterior, which makes them more impervious to moisture and more durable than ordinary wood of the same weight. The presence of partitions at short intervals, which cut up the hollow stem into natural receptacles, is another valuable characteristic. These partitions can, however, be easily removed, and the hollow stem used as a pipe, or the pipe can be split open from end to end to form two semicylindrical troughs. The ease with which the green stems can be split into slender pieces, which range in size from half that of the stem itself to the fineness of a horsehair, is one of the most remarkable qualities of the wood, and makes it adapted to innumerable kinds of basket, sieve, screen, and mat making. The fact that no long process of curing is necessary before stems which have been cut fresh from the forest can be used is one of the qualities that makes the plant of such great convenience in the peasant homes of the Orient. Many of the articles of bamboo manufacture could be replaced by metal ones, but it is the convenience of having always at hand a stock of material which can be easily made into a host of improvised things that makes the plant so valuable. This latter is a point which should appeal especially to Americans, who are called the handiest people in the world.

The employment of the young sprouts as a vegetable is alone worthy of the serious attention of our cultivators, for the fondness which many American residents show for bamboo shoots indicates the possibility of creating a demand for them in America.

But in addition to the uses of the bamboos as timber and food plants their value from an æsthetic standpoint is incontestable. They are among the most graceful forms of vegetable life that exist, and add an indescribable charm to any landscape (Pl. I). No one who has

.r seen them in China or Japan can fail to have been impressed th their beauty or convinced of the great charm which they lend to e otherwise often monotonous character of the scenery. They are wing plumes of delicate green foliage, which, whether seen against e sky line or backed by a darker mass of forest, always give a peculr softness to the scene.

Nearly every farmhouse has growing near it a clump of some one the useful species, and the graceful mass of culms transforms what ould be an uninteresting plaster and tile house into a pretty, picturque home.

It is, however, the introduction of the hardy representatives of this markable family of plants into the United States that should attract e attention of Americans, and the object of this bulletin is to show w the various kinds of bamboo are cultivated in Japan, and to ggest how these methods of cultivation can be applied to American nditions.

As might be expected, in a group of plants containing hundreds of ecies, there is a great range of hardiness among them. Some of the panese forms are able to thrive in the coldest regions of Hokkaido, e North Island, while others are too tender to be grown successfully en in the comparatively mild climate of the central provinces.

There is also a great range in the size of the different species. Some so small that they creep over the ground, forming a reed-like, rankowing greensward (Pl. VII, fig. 2), while others grow to a height 40 feet or more and produce stems which are 6 and 7 inches in meter (Pl. IV). Certain forms are suited only for potting purposes l are chosen by the Japanese gardeners as objects upon which to ctice their dwarfing art (Pl. VII, fig. 1), while others are grown in ests which are many acres in extent.

While the introduction into America of some of the smaller forms desirable matter, the main interest attaches to securing and estabing the hardy forest species.

As previously remarked, there are many plants of Japanese bams already growing in America. Clumps of the very hardy kinds y be seen occasionally in private gardens or public parks in the th, even as far north as Washington; but owing either to the diffiy of getting the plants or a failure to understand their managent these have never become popular farm plants. Potted specimens the small species are to be met with in many florists' collections, and e are used as lawn plants, but the employment of even these is y limited.

n California, where the Japanese and Chinese species thrive very l, there are many large specimens, and even one small forest, while mber of Californians are enthusiastic bamboo fanciers. Dr. H. is, of San Francisco, has probably the largest collection on the

Pacific coast, and his brother has a grove at Bakersfield in which stems over 40 feet high are said to be growing. The Golden Gate Park has several clumps which are very promising, and Mr. McLaren, the superintendent, was most enthusiastic over an offer by Mr. Lathrop to present several thousand to the park, with which to start a grove or two of more than a half acre in extent. In the grounds of a nursery company at Niles, Cal., there are several rows (Pl. VIII) of the timber bamboo, individuals of which are certainly 25 feet in height; and a beautiful little grove, probably of *Phyllostachys quilioi*, in the town of Berkeley, was destroyed a few years ago to make way for a street. In Florida the well-known nursery firms have already imported many different species.

Mr. Lathrop is assisting the Department of Agriculture in an attempt to introduce on a large scale the best of the Japanese timber sorts and arouse the interest of a large class of cultivators in those regions where the plants are likely to succeed, and it is to be hoped that the time is not far off when many thousands of young plants will be set out through these sections of the United States.

GENERAL CHARACTERS OF THE JAPANESE BAMBOOS.

Bamboos are not trees, although their stems or culms are sometimes as large as tree trunks, and it is essential that their character as grasses be kept in mind.

They have the power of producing seeds, which resemble (in Japanese species, at least) kernels of rice or barley, but they flower as a rule only at intervals of many years, and very few of the flowers ever form seed. The formation of mature seed is so uncommon in Japan that Mr. Makino, of the Tokyo Botanic Gardens, who is writing a monograph on the family, says he has never seen the seed of certain of the common species.

In the almost total absence of the method of reproduction by seed the bamboos have developed their rhizomes, or underground stems, and it is upon these that the spread and multiplication of the individuals depends. Unlike an ordinary tree, therefore, a clump of bamboos has underground stems in addition to its root system. A mass of these creeping rhizomes, which grow out in various directions from the base of the clump, give rise every year to the new shoots which increase the diameter of the clump. A single rhizome, according to Dr. Shiga, chief of the bureau of forest management in Tokyo, continues growing for four seasons and then ceases, but from the bases of the shoots it produces new rhizomes grow out which have a similar period of growth. If these underground stems or rhizomes are injured or checked in any way from spreading freely through the soil, the clump of aërial shoots will remain small; but if given rich soil and abundance

of moisture a few plants will spread gradually until they cover a considerable area.

The new shoots of bamboo are produced by different species at different seasons of the year. The majority of Japanese species send up their new stems in the spring, beginning in April and May, and it is these sorts that stand the best chance of succeeding in America, because our cold winters will kill back any young growth produced late in the summer.

This growing period is the most critical one in the life of the plant, as the shoots during development are easily injured by winds, frosts, or droughts, and it is upon the growth of these young stems that the beauty of the clump during the summer depends.

If one examine a rhizome of bamboo (Pl. VI, fig. 3) it will be seen to have at short intervals partitions or nodes, above each of which is situated a small pointed bud, and from each bud arises a number of fibrous roots. It is by the elongation and thickening of these buds that the new shoots are formed, and if it is injured, though the rhizome may remain alive for many years, it will not produce any new buds or shoots from these nodes.

When a bud at the node of one of the underground stems has swollen until it is much larger in diameter than the rhizome which supports it and has sent down a number of good, strong roots, it begins to elongate and push its way up through the soil. Tough, overlapping sheaths protect the tender tip from injury, as well as the undeveloped branches on the sides of the elongating shoot. These sheaths are borne on alternate sides of the stem by each internode or joint (Pl. IV, fig. 1), and are, according to Sir Ernest Satow, characteristic of each species.[a] They are tough and board-like, many of them, often covered outside with fine bristles and characteristically marked; and the tip of each is provided with a leaf-like appendage called *pseudophyll*, which varies in shape with each species. These protecting organs remain closely attached to the stem until it has nearly finished its growth, when they stand out from the stem, allow the young branches hidden beneath to develop, and finally drop off. In some species the sheaths remain attached longer than in others, and in certain species they never drop off, but gradually dry up and break to pieces.

Until the young stem has attained its full height it is quite branchless, like a shoot of asparagus. On reaching maturity, however, the sheaths fall back and the young branches elongate and unfold their leaves. Most large forest bamboos have no branches near the ground, the first four or six nodes failing to produce them. When grown in

[a] The Cultivation of Bamboos in Japan. Trans. Asiat. Soc. Japan, Vol. XXVII, Part III, 1899. Price, 5 yen.

dense masses even the first twenty or more are often devoid of branches. The smaller the shoot the more likely it is to branch from the lower nodes.

The leaves of bamboo vary greatly in size, but have one general lanceolate form, some being nearly a foot long by 6 inches wide, and suitable for wrapping material; but the majority of forest forms at least have leaves from 2 to 6 inches long. Mr. Mitford points out in his most interesting book, "The Bamboo Garden," that the leaves of all hardy species in England have not only the parallel longitudinal nerves which are common to all bamboos, but delicate cross nerves which give a leaf the appearance, when held up to the light, of being covered with a network of veins. All species tested by him which did not have these "*tesselated*" leaves, as he calls those leaves with cross as well as longitudinal veins, proved tender in England.

Little use is made of the foliage of most species of bamboo, a few only being used for fodder where better food in not obtainable. One species in *Hokkaido* is said to be browsed over by the few cattle which are there. When first produced the young foliage is often of a dark-green color, but as it becomes older it changes to a lighter shade of green, and on very old culms it often has a yellowish tinge. These differences in the color of the foliage are what give such a variable appearance to a bamboo forest.

Although produced in a few weeks, a stem requires three or four years to harden and become fit for use, and if left standing in the forest too long, or until it becomes yellow, it loses much of its elasticity. Culms that are twenty years old have lost much of their beauty, the foliage becoming scant and the stems yellow and scarred.

The roots of the bamboo resemble those of Indian corn. They are brittle and easily broken and are never of any great size, but are formed in large masses from the nodes of the underground stems.

PROPAGATION OF JAPANESE BAMBOOS.

If Japanese bamboos produced seed, the cheapest and safest way to propagate them would be by importing large quantities of the latter and growing them in seed beds; but as none of the useful species bear fruit, except at very long intervals, it is necessary to propagate the plants by other means. Two methods have been practiced, one of which, however, is only used to a limited extent.

The safest way is the simple one of digging up young plants, separating them from the mother clumps, and transplanting them to the desired situation. This method seems very simple, but there are several essential points regarding it which must be attended to if the transplanting is to prove a success. If the transplanting is only from a forest to a location near by, it may be done at any time during

the growing season. In Japan this period extends from April until July, inclusive. If, however, the plants are desired for planting in a foreign country, America, for example, they should be dug early in April, set out in nursery rows, and allowed to grow until the middle of July. Those which in July show a new growth from the rhizome should then be transplanted again into the same kind of soil, and in October they will be in condition for digging and shipment. Mr. Tsuboi, of Kusafuka, cuts back the culms on his young plants to one or two nodes when he first digs them in April, at which time they form a rosette of leaves near the ground (Pl. VI, fig. 1). When treated in this way they produce small plants which would be very economical for shipping, as they require little box space.

Much depends upon the selection of the young plants whether or not a vigorous clump results from its planting in a few years. The mother plant should be inspected to see if it is in good health. If the branches are affected by what is known as "witches' broom," which makes gnarled, irregular tangles of the small branches, young plants should not be taken from them. A species of smut (Ustilago) sometimes affects the young branches and produces an appearance similar to that of the witches' broom, but this is less abundant than the former disease. The larva of a species of beetle, whose habits are not yet fully known so far as could be ascertained, sometimes causes considerable damage by boring into the young shoots and penetrating through segment after segment of the young growth, stunting the culm and completely ruining it for timber purposes (Pl. VII, figs. 3 and 4). A young plant in bloom is considered worthless for transplanting, as it seldom gives rise to new shoots.

The proper way is to select a young plant with branches near the ground and cut down with a spade or other cutting tool on all sides of the base at a distance of not less than 8 inches, severing the rhizomes which connect the plant with the mother clump. Dig out a good-sized ball of earth with the roots inclosed in it, shake off the superfluous earth, cut back the stem to two branch-bearing nodes, and transfer to nursery row (Pl. VI, fig. 2). If no rhizome is dug up with the plant, or if the rhizome is dead, the plant may live on for several years, a rosette of leaves forming at the top of the stem, without the formation of any new shoots (Pl. VI, fig. 2). Mr. Tsuboi is of the opinion that plants with dead rhizomes will live for seven or eight years and appear perfectly healthy. The plant is kept alive by the fibrous roots, but has no power to form a new rhizome. In the purchasing of plants from nursery companies the principal point to ascertain is whether the rhizome is alive and in vigorous condition. The part above ground may be to all appearances in good health, while the rhizome is dead, making the plant worthless.

If these properly dug plants which have been set in nursery rows

in April are inspected in July some of them will have begun the formation of new shoots from their active rhizomes. Plants of which the rhizomes show no signs of activity, it should be emphasized, are probably weak and should not be chosen for the second transplanting, especially if designed for a long ocean voyage. In October the twice-transplanted bamboos, hardened by this transplanting process, are dug and their roots, together with a ball of earth, are wrapped with coarse straw twine, surrounded with a layer of moist sphagnum, and packed carefully in well-aired boxes. All holes in such boxes should be carefully closed with wire netting to keep out rats during the voyage. Very little foliage should be left on the plants when they are shipped in this way (see Pl. VI, fig. 2). October is the best month for shipping from Japan, because the plants have by that time gone into a dormant condition and travel safer, and the extreme cold weather will not have begun before they reach their destination in America.

Even with these precautions, the plants on arrival after a sea voyage require special attention. According to Mitford, who has had much experience with their importation, they should not be planted out in their permanent places before they have recovered from the effects of the journey. The balls of earth should be first thoroughly soaked in water and the plants then potted and placed in a cool house for the winter. The leaves, or bare culms, if the leaves are lost, should be copiously syringed twice a day, but the roots should not be kept too moist. Early in May the plants should be hardened off as one harden off geraniums for bedding out, and at the end of May or beginning of June they will be ready to plant in their permanent places.

This should be in soil which has been especially prepared the previous autumn by double digging to a depth of 18 inches. In setting out, great care should be taken not to trample down the soil too roughly about the roots, as there is great danger of injuring the brittle buds on the rhizomes or the tender fibrous roots. It is best, Mr Mitford says, to consolidate the plants by watering freely. After planting, the ground should be thickly covered with a mulch of dried leaves (Pl. II), under which is a layer of cow manure; and this mulch should be kept on during the summer months to allow the plants to form a good strong system of underground stems and fibrous roots.

The above method, which embodies the experience of such students of the bamboo as Mr. Mitford, Mr. Tsuboi, and Mr. H. Suzuki, is probably the safest one and in the end most economical.

It has been found unnecessary by such cultivators as Mr. J. McLaren and Mr. John Rock, of California, to pot the plants on arrival in such a warm climate as California. They are merely heeled in, given plenty of water, and set out the following spring.

The other method of propagation is to dig up, in the winter, length

of 1-year-old rhizome 3 feet or so long, rub the cut ends with wet ashes, allow these wet ashes to dry, and pack carefully in a tight box in fine, almost dry soil (Pl. VI, fig. 3). Upon arrival these rhizomes are set out in properly prepared ground. The shipment should be timed to arrive at its destination in the early spring, so that the cuttings can be set out at once. This method is recommended by Mr. Mitford for the commercial nursery propagation of the bamboo, but he does not advise its employment if the plants are to be shipped long distances, and the author has failed to find that it has been successfully tried. Mr. John Rock, of Niles, Cal., thinks bamboos could be propagated quickly in this way.

Even with the best of care in transplanting by the first described method the Japanese bamboo growers count on losing at least 10 per cent of their young plants, and if the conditions are not altogether favorable, as high as 20 per cent of failures may be expected.

SUITABLE LOCATION AND SOIL CONDITIONS FOR BAMBOOS.

In Japan some of the best groves are surrounded by paddy fields, and the soil is a rich, stiff loam, lightened with a mixture of sand. Those visited by the writer are on the open plain and stretch up and down a small brook for 5 miles or more. Whatever winds blow over this small plain must strike the forests, but it is safe to say that such winds are not strong ones. A favorite site for a bamboo grove is the base of some range of hills or a broad valley where some mountain stream has brought down and deposited a mass of alluvium. These situations have the double advantage of suitable soil and shelter from strong winds. This latter point is said by every grower to be an important one, for the young shoot, as soon as it is tall enough to come in contact with the branches of the older ones, is thrashed about by the winds and its growing tip is injured. This injury stops its growth at once and the resulting culm is imperfect. Wind-breaks of conifers are sometimes planted to protect a grove which is in an exposed position. In America, where the prevailing winds are probably as a rule stronger than they are in Japan, special attention will have to be given to this matter of wind-breaks.

The quality of the soil on which a bamboo stem is grown influences materially the texture of its wood. So fully is this realized by the Japanese that there is one particular mountain side which has the reputation of producing the hardest, flintiest bamboo in the country. The culms grown at Togeppo are cut up and made into the cylindrical ash boxes, or "haifuki," upon the edge of which the smokers strike their metal-trimmed pipes in order to knock out the ashes. After years of use the edge of the Togeppo ash box remains smooth, while that made from a stem grown in the lowlands is splintered to pieces.

Potash and phosphoric acid are very important elements in the formation of a strong, tough wood, and although their use in fertilizers does not make so much difference in the rapid growth of the culm as that of nitrogen they are quite as important.

A well-drained soil is just as necessary for bamboos as for many trees, for although these plants require much moisture they are not swamp plants, like canes or reeds. Land which is occasionally overflowed can be planted to advantage with bamboos, according to Mr. Tsuboi, if they are set on low mounds or ridges; but stagnant pools of water will kill the rhizomes if allowed to stand over them for many weeks. Embankments of canals, the borders of ponds, and river banks are suitable situations, especially in dry regions. Large clumps are growing along the canals in Egypt, and Algiers has many varieties growing in her trial gardens which are watered only by irrigation. There are in California, Oregon, Texas, and throughout the Gulf and Southern States thousands of suitable locations. The banks of small streams, the deltas of rivers, low, irrigated islands, like those in the San Joaquin and Sacramento rivers, would produce big forests of these valuable plants, while the banks of irrigation canals, wherever such occur in mild climates, could be made beautiful by them. Any soil which has a large admixture of gravel in it does not prove satisfactory, as the gravel prevents the rapid spreading of the underground stems. Such compact soils as the gumbo soils of the Southwest will probably grow the plants well, but they will presumably not spread as rapidly on such stiff ground as they would upon a lighter loam. If it is the object to produce a large number of big culms, the best soil is one with a fair admixture of vegetable humus. The rhizomes spread rapidly in such humus and produce a fine crop of new shoots. As the roots of the forest species penetrate 3 feet into the soil, the writer is assured that a clay subsoil at this depth is a desirable soil condition. In the cultivation of the edible bamboos (*Phyllostachys mitis*) a lighter, more sandy soil seems to be preferred to that deemed suitable for the timber kinds, *P. quilioi* and *P. henonis*. Most bamboos will not withstand much drought without losing their leaves, but they are not so dependent upon a moist atmosphere as most people imagine. If they are supplied with plenty of water at the roots their leaves will keep green in a fairly dry climate. They must not be considered, however, as drought-resistant plants, but as suitable for irrigated land or regions in which there is at least a moderately regular rainfall. At Niles, Cal., Mr. Rock has bamboos 20 feet high which are watered only twice a year with about 2 inches of water each time (Pl. VIII).

JAPANESE MANAGEMENT OF BAMBOO GROVES.

One of the best posted bamboo growers in Japan informed the writer that twenty years ago he did not know that his groves, which were then in a neglected state, had any money value, but that to-day those parts of his farm on which the groves are situated are its most valuable portions. The attention which he bestows upon them now is very inexpensive, but almost as careful as that given to any other of his crops. The following forest methods are largely those which Mr. Tsuboi described as, from his experience, the best. These are applicable with slight variations to the three principal timber bamboos in Japan, and pertain in a general way to the culture of the ornamental species.

The land chosen for a bamboo grove should be dug over to a depth of 1½ feet the autumn previous to being planted, and, if a heavy soil, should have worked into it a good quantity of trash from the stable. The plants should be set out at an equal distance from each other at the rate of about 300 to an acre, or 12 feet apart each way. If the soil is a dry one, the ball of earth and roots should be planted below the surface of the soil, but if a wet one a mound should be made and the plants set in the upper portion of it. After planting it is important, as already remarked, that the soil between the plants should be given a heavy mulch of straw, under which is a layer of cow manure. This mulch should be maintained during the entire year. In the beginning the roots should be supplied with an abundance of water and in the autumn should be given plenty of rotted manure. If some of the plants die, they should be replaced by others so as to maintain as complete a stand as possible. It is essential as the new shoots spring up, that the ground at their bases should be shaded by the foliage. The semiobscurity of a Japanese grove is not only its greatest charm, but one of the necessary factors of its growth. The sooner the ground can be shaded by the plants the better.

For the first three years at least all the shoots that appear should be allowed to mature, but after the grove is once well established only the largest shoots should be permitted to grow, the others being cut out as soon as they appear above the ground. This thinning process throws the strength of the plants into a comparatively few large culms, and gradually increases the height and strength of the forest.

In regions where the snows are so heavy that they break down the plants the practice of bringing the tops of several culms together and fastening them with rope is sometimes followed. The wigwam-like masses formed in this way are able to support without injury the weight of snow.

No culm should be cut for timber purposes until it is at least four years old, as before this time the wood is not mature. On the other

hand, if left standing too long the wood becomes too brittle and loses in value, and the forest besides is benefited by the cutting out of the four-year-old stems. The crop of new shoots is larger. This thinning-out process should be so done that as few gaps as possible are made in the forest and the semiobscurity below the mass of foliage is maintained.

The crop of new shoots varies in size every alternate year. A poor crop would mean 6 to 7 per cent of new shoots and a good crop 12 to 14 per cent. As there are commonly 10,000 culms in a hectare[a] (or 4,545 in an acre) of properly planted grove ten to fifteen years old, this would mean the production of 600 to 700 culms per hectare for a light crop and 1,200 to 1,400 for a heavy one. These figures were very kindly furnished the writer by Dr. T. Shiga, chief of the imperial forest management in Tokyo.

The experience of Mr. Tsuboi has been that some kinds of forest trees if standing in a grove prevent the growth of the bamboos near them. Oaks and chestnuts, he declares, are especially objectionable in this respect, while persimmons do not seem to affect in the least the production of new bamboo shoots. The effect of weeds in a forest is undesirable, and although comparatively few species are able to live in such a deep shade these should be dug out as from any cultivated field. Attention to these various details makes a great difference in the amount and quality of timber produced. A grove is not to be looked upon as merely a thicket and left to take care of itself, but as a plant culture which requires attention. Plates II and III show the effects of different methods of treating parts of the same grove.

One important element in the culture of this peculiar timber plant is the fact that a whole forest may bloom and die in a single season, and that it is not possible—as yet—to tell beforehand when this blooming will take place. The intervals between these periods are, however, so long that they are not taken into consideration by the Japanese farmer when he buys a bamboo grove. Little accurate information is obtainable regarding the length of life of the various Japanese species, but *Phyllostachys henonis* has the reputation in Japan of blooming oftener than either *P. quilioi*, *P. mitis*, or *P. nigra*, the other three important timber species. A small grove near Kawasaki which bloomed this season (1902) was reported by the owner to have once bloomed about sixty years before. As there always remain in the field a number of living rhizomes, after the death of the forest, these renew the latter in a few years, so that the actual loss to the owner does not include the cost of replanting. This is the case at least with the Japanese bamboos. As culms which have bloomed are poor in quality, the practice is followed of cutting them as soon as possible after they show signs of blooming.

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[a] About 2½ acres.

In Japan, where bamboos and rice are often grown in adjoining plats of ground, some trouble is experienced from the underground stems spreading into the neighboring fields. To prevent this a ditch 2 feet wide and as many feet deep is dug about the grove and kept open by several rediggings during the year. This method is said to be a satisfactory one. It is a difficult matter, however, after a field has once been planted to bamboos, to clear it satisfactorily for other crops, for there is a mass of these tough rhizomes that are very difficult to dig out.

The harvesting of bamboo poles is not done before August, as culms cut earlier than this date are likely to be attacked by insects, not having had time to sufficiently harden. A Kyoto grower of black bamboos remarked that the Kobe exporters, by insisting on having their bamboos for export cut earlier than this date, had seriously injured the foreign demand, as the quality of the wood was much injured by this early harvest.

A saw is often used in cutting the shoots, by making cuts on opposite sides of it near the base. When cut, the poles are classified, tied into bundles, and stacked like hop or bean poles to dry. In the lumber yards of Japan these stacked poles of bamboo form a prominent feature.

PROFITS OF BAMBOO CULTURE IN JAPAN.

Dr. Shiga, chief of the bureau of forest management of Japan, when asked whether bamboo growing was profitable or not, said promptly that it was the best paying plant culture in the country, yielding a net return of 250 yen per hectare, which is the equivalent of about $50 gold per acre. The species referred to by Mr. Shiga in this case was the edible one. Twenty per cent of this amount represents the profits from the sale of edible shoots. Mr. Tsuboi's profits on his groves of *Phyllostachys quilioi*, a strictly timber species, averaged $20 an acre, while those of one of his friends near Kyoto were $40. The profits of a good grove of edible bamboo are evidently greater than those from one grown for timber only, and the author was informed by one of the best bamboo growers near Kyoto that his profits per acre were about $90 on land which, cleared of bamboo, would not bring more than $80, while good rice land sold for $200. A second grower of bamboos near Kyoto, who ships for the export trade from Kobe, informed the writer that the culture in his province of *Phyllostachys quilioi* yields a net income of about $40 per acre, while *P. henonis* brings in only about $30. Five years ago the black bamboo brought in a profit of $200 per acre, but now scarcely nets $50. Rice culture in this region, according to Mr. Tsuboi, barely pays more than for the cost of labor and manure, the former reckoned at 35 to 40 sen, or 17½ to 20 cents gold, a day. All of these figures, however,

have no practical bearing on the profits of bamboo growing in America, where a market for the culms can only be made after a constant reasonable supply has been assured.

The cost of the attention which is necessary in order to grow bamboos is so much less than that required for rice growing, suitable land is so much cheaper, and so much less risk is run from bad weather, that the statement that it is the best paying culture in Japan seems correct, and such inquiries tend to confirm it.

CULTURE OF THE EDIBLE BAMBOO.

Only one species of bamboo is commonly grown in Japan for food, and this is the largest one (*Phyllostachys mitis*), known as "Moso." It was introduced from China, where its value as a food plant has been known for centuries, and its common name indicates its origin.[a] One other sort, *P. aurea*, is also said to have edible shoots, but those of the remaining kinds are understood to be too bitter to be eaten.

The method of cultivating this species differs from that described for the timber sorts. The best soil is a more friable one, and if not naturally with a good admixture of sand it must be top dressed every year with 1 inch of light sandy loam and a mulching of straw or grass and weeds cut from the meadow. The young plants are set out more sparsely than if designed for timber, not more than 120 to the acre. Liquid manure is given freely to the newly set out plants, and as long as they are grown for their edible shoots large amounts of rich fertilizer containing much soluble nitrogen must be supplied them. In Japan the cost of the fertilizer is the principal expense of cultivation. In five years, if the transplanted mother plants are of good size, they should yield shoots large enough for sale, but ten years are required to bring the plantation into a profitable bearing condition. Weeding is done more carefully than in timber groves, though for the first five or six years all the shoots which come up are allowed to stand; but later, when the plantation is established, all small-sized ones are promptly removed as soon as they appear above ground. In order to obtain a supply of fresh culms a regular system in cutting out the old ones is followed. A definite number of selected stems, as soon as they are fully grown, are marked with the year of their production, and nine years later all of those bearing the same date are cut out. Each spring the same number (about 80 per acre) of new culms are spared from being dug out when small for market, and each autumn a similar

[a] Moso is the name of one of the twenty-four paragons of Chinese filial piety. The story is the case of a boy whose widowed mother fell ill and longed for broth made of young bamboo shoots. The shoots not being procurable in winter, his devotion was such that he went out in the snow to dig for them. The gods rewarded his devotion by causing the shoots to grow suddenly to an unheard-of size. Japanese artists are fond of illustrating their works of art with drawings of the boy Moso.

number of 9-year-old stems are cut and sold for timber. These are only a small proportion of the total number of bamboos on an acre, for this ranges from 640 to 680. If this system of thinning out is followed a plantation may be kept in bearing almost indefinitely. Near Kyoto the practice is followed of cutting off the top of every shoot left standing, before it is fully mature, to a height of from 12 to 14 feet. This prevents the wind from moving the culms too much and induces the formation of a bushy mass of luxuriant foliage and a great number of medium-sized shoots, which are more profitable than the few larger-sized ones that result if the mother plants are not topped.

The tenderest shoots and those which bring the highest prices are he ones dug up before their tips have pierced the surface of the soil. These bring, early in the season, as much as 1 yen per "kwan" (about 5 cents gold per pound), while the later product must sometimes be lisposed of for a tenth of this price. The market season in Tokyo egins in December and closes in June. Although bamboo shoots are very nutritious, they are not easily digested, and many Americans do not like them for this reason. Old residents in Japan, however, often grow very fond of them and have adapted them to their Western menu.

Miss Fanny Eldredge, of Yokohama, has very kindly furnished the following recipes for cooking bamboo shoots:

1. *Bamboo sprouts with cream sauce.*—These sprouts are cut when about a foot above he ground, by digging down to the rhizomes which bear them. After being gathered, the outside sheaths are removed and the shoots are soaked for half an hour n cold water. They are then cut in thin slices, about 3 inches long by 1 inch square, and thrown into boiling water containing a small teaspoonful of salt, and are boiled rom an hour to an hour and a half, or until tender. The pieces are then drained and a white sauce is poured over them, which is made in the following way: To a alf pint of cream or milk add a teaspoonful of butter; season with salt and black epper. Allow this to boil up and serve at once. If desired, this sauce may be hickened with flour.

2. *Bamboo shoots in butter.*—Slice and cook as in the previous recipe, until tender. nto a saucepan put three tablespoonfuls of butter, seasoned with pepper, salt, and a ittle chopped parsley. When heated, put in the bamboo. Shake and turn until he mixture boils; then lay the bamboo on a hot platter, pour the butter over it, and erve at once.

3. *Bamboo shoots, Japanese style.*—Slice and cook the bamboo until tender, as in ecipe No. 1; then put into a sauce made as follows: Take one coffee cup full of soy auce (this is the basis of Worcestershire sauce and obtained only at Chinese or apanese grocers or at some of the largest groceries in our large cities), one-fourth upful of water, one heaping teaspoonful of sugar; let boil for half an hour in this auce, and serve.

DIFFERENT SPECIES OF BAMBOOS.

The bamboo family is a large one and scattered over a great portion f the warmer and mountain regions of the globe, and, owing to the act that the plants so infrequently bloom and that their classification

depends upon the characters of the flower, it is not a very well-known group of plants. The monograph by Munro[a] is one of the most comprehensive attempts to give in one book descriptions of all of the known species. Of the hundreds of described forms only a small proportion are of much economic importance, and of these only a few are hardy. When the interior of China, the slopes of the Himalayas and Andes, and the mountains of the Malay Archipelago have been searched over for valuable hardy forms, the comparatively short list of species suitable for introduction will doubtless be largely increased. Anyone wishing to know what a large territory there is to search over for hardy bamboos and how many remain to be introduced and tested, will find these subjects discussed in a very interesting chapter called, "Future possibilities," in Mr. Mitford's book, "The Bamboo Garden." Nor should attention be confined to the hardy forms, when the tropical species are so many and various and have been so little studied from an economic standpoint. There are forms in Burma which could doubtless be introduced with great advantage into the Philippines, and species from the semitropical regions of China which are worthy of establishing in Hawaii. In fact, the more familiar one becomes with the bamboo question the truer does Mr. Mitford's statement, from the æsthetic standpoint, appear, that "we have only touched the fringe of what we may hope to achieve in the decoration of our wilderness gardens with the grace of these royal grasses."

At present, only a limited number of forms are eligible for introduction into the United States, and the majority of these are found in Japan.

The following popular descriptions of the more important economic sorts are given to assist in determining those common species which may be introduced in the near future, or which are already growing in America. The nomenclature followed is that given by Mr. Mitford in his "Bamboo Garden," except in such species as are not included by him, when Sir Ernest Satow's work, "The Cultivation of Bamboos in Japan," is followed. This is not an attempt to clear up the nomenclature of these badly mixed species.

The different common species of Japanese bamboos which resemble each other have been so often taken for one another that a convenient method of telling them apart is a very desirable thing. Such a method Sir Ernest Satow has drawn attention to in his book. It consists in comparing the forms and markings of the sheaths that surround the young shoots and in the leaf-like appendages or pseudophylls which are borne at their tips. He has published colored plates to illustrate

[a] Monograph of the Bambusaceæ, including descriptions of all the species. London, 1870, 157 pp.

hese characters. The difficulty in using them, however, is that the heaths are only obtainable in the season when there are young shoots. Mr. Mitford points out that the form and coloration of the winter uds in the axils of the branches, from which new branches develop, re important means of distinguishing the species. The characters which determine whether a bamboo belongs to the *Bambusa*, *Phyllostachys*, or *Arundinaria* genera, which are all it is necessary to conider here, are unfortunately largely floral ones and for practical urposes nearly useless. The genus *Bambusa* belongs to a section Bambusæ veræ) in which the flowers have six stamens, while *Phyllostachys* and *Arundinaria* both belong to the *Triglossæ* section, where e flowers have three stamens. *Arundinaria* is distinguished from *Phyllostachys* by having round stems, while those of the latter are rooved or slightly flattened on one side. The sheaths in *Arundinaria* emain attached much longer than in *Phyllostachys*, as a rule those of e latter genus dropping off as soon as the culms are mature.

Phyllostachys Mitis, A. & C. Rivière.

(Japanese name: "*Moso-chiku*" or "*Mouso-chiku.*")

The largest hardy species in Japan, growing to a height of over 50 eet and producing, not uncommonly, culms over 6 inches in diameter. n England specimens have been grown to a height of 19 feet and a iameter of 1½ inches. *The culms are gently curved shortly after leaving the ground*, while those of other sorts with which it might be conused rise straight from the base. (Compare figs. 1 and 3, Pl. IV.) s sheaths are of a light-brown color, *marked with dark amber-brown otches and round dots* and covered with bristles. The pseudophyll is road at the base, tapers to a point, *but is not wavy in outline.* The sheath preads right and left from the base of the pseudophyll and is fringed hroughout with hairs, which are straight when they lie between the seudophyll and the stem, but curled on the right and left sides where ey are free to develop. The internodes are generally shorter than ose of the other large species and *the leaf sheaths are fringed at the nsertion of the leaf with a number of rather coarse hairs.* The branch uds are purplish brown and strongly marked. The leaves vary from to 6 inches in length and are too variable to be convenient characters or quick determination. This is the great edible bamboo of Japan nd China, the method of cultivation of which has been described. It not as hardy in England as *Phyllostachys quilioi* and *P. henonis.*

Phyllostachys Quilioi, A. & C. Rivière.

(Japanese name: "*Madake.*")

The second largest hardy species, growing to a height of 30 to 40 eet in Japan and 18 feet in England, with a diameter of 4 inches and inches, respectively. The great timber bamboo of the Japanese.

The culms rise straight from the rhizome, and the branches are proportionately long, compared with the height of the stem.

Its sheaths are marked with *purple or reddish blotches, which are much more pronounced in character than those of the preceding species, and the pseudophyll has a wavy outline.* The branch buds have green bases, and only the tips are brown. The new shoots appear above ground in Japan a month later than those of the following species (*P. henonis*), that is, in June. The internodes are proportionately longer than those of *P. mitis*, but the leaf sheaths are fringed with long hairs, as they are in that species. The leaves vary in length from 2 to 8 inches, but are proportionately broader, according to Mitford. This species is hardy in England and has a more vigorously spreading rhizome than that of *P. mitis* or *P. aurea.*

Phyllostachys Henonis, Mitford.

(Japanese name: "*Hachiku.*")

A somewhat smaller kind of bamboo than the preceding two species; Considered by Mitford the prettiest one cultivated in England. Height in Japan from 20 to 30 feet, with a maximum diameter of a trifle over 3 inches. In England specimens 14 feet high and one-half inch in diameter occur. After *P. mitis* and *P. quilioi* the commonest timber form in Japan. Culms rise straight from the base. *Sheaths are a straw color, with few or no spots of any kind and with a distinctly wavy pseudophyll* like the blade of a Malay *kris.* New shoots appear before those of *P. quilioi*—that is, in April and May. The leaf sheaths are fringed (at least on young plants) with delicate hairs, which are *neither so long nor bristlelike as those in P. mitis and P. quilioi.* Branch buds are a pale yellowish-green. The pipe is thinner walled than that of *P. quilioi*, and its use in the arts is restricted because of the inferior quality of the wood. The rootstock is said to run freely in England, where it has proved hardy.

"Madaradake" or "Ummon-chiku."

A form closely related to *P. henonis*, which is distinguished by having dark blotches on its culms that are presumably caused by some as yet undetermined species of fungus. These spots are regularly present on almost all internodes and give to the stems a very decorative appearance, making them much sought after for fancy furniture. The extent and beauty of these blotches vary with the amount of shade which the plants are given and the kind of soil upon which they are grown. The best location is said to be a moist river bottom, and the less direct sunlight that is permitted to strike the young shoots when in growth the better. A rare sort, except in certain localities in Japan. Some of the best groves the writer has seen are in Hikone, in the province of Mino, on Lake Biwa.

Phyllostachys Nigra, Munro.

(Japanese names: "*Gomadaké*," "*Kuro-chiku*," or "*Kurodaké*.")

The black bamboo is not as generally grown in Japan as the three ecies just mentioned, but it is nevertheless an important culture. ormerly more money was made out of it than has been the case in cent years, because the foreign demand, it is said, has fallen off.

It is a smaller species than the other timber sorts, seldom growing ver 20 feet high and 1½ inches in diameter.

The culms when young are covered with dark-brown to purple spots, hich spread as it grows older until the whole culm becomes dark-rown, almost black, except just below the nodes, where there is an h-gray line. This dark color at once distinguishes the species from l other Japanese sorts. Branch buds are brown, mottled with black. here is a great variation in the intensity of this dark color of the culms, d this is said to vary with the kind of soil upon which the plants are own and the amount of sunlight to which they are exposed. There , however, at least two varieties of this species, one with much more tensely brown culms than the other. Mr. Mitford calls the lighter rt *P. nigro-punctata*, and remarks that it is hardier than *P. nigra*, it not so pretty. Light, hillside soil is claimed as better adapted to e production of intense color than rich alluvium, and it is found cessary to renew old plantations, in order to prevent the color from ding out.

This is one of the hardiest forms grown in England, attaining in ceptional cases 20 feet in height, and it is certainly one of the most corative kinds. Nothing could exceed the delicate beauty of the oves of this species which are to be seen near Kyoto. Their dark ms, ash-gray nodes, and light-green foliage make them unique nong decorative plants. (See Pl. I.)

The uses of this species are limited to the manufacture of furniture, merous household articles, and fancy fishing poles, for all of which ese black bamboos are peculiarly suited.

Phyllostachys Castillonis.[a]

(Japanese name: "*Kimmei-chiku*.")

The golden-striped bamboo is one of the most decorative forms of group. It is not easily confused with other Japanese sorts when characters are fully developed, for each culm is of a beautiful lden-yellow color, striped with brilliant green. The leaves also are riegated with stripes of green and white. The contrast between golden yellow of the stems and the green stripes on the young

[a] No authority is given by Mitford for this name, and the author has been unable et to work out its correct name. The nomenclature of the bamboos needs work-over.

shoots is one of the prettiest effects imaginable. The species grows occasionally over 30 feet high in Japan and specimens 5 to 6 feet high are already found in England, where the species has withstood a temperature of 24 degrees of frost or 8° F. It is not a common species even in the gardens of Japan, and Mr. Mitford says it is uncommon in England. Very young plants sometimes show only slight traces of the variegation on the stems, but develop this character later.

Mr. Tsuboi, who has the most exceptional taste in bamboos, and in the dwarfing of which he is an acknowledged connoisseur (see Pl. VII fig. 1), suggested planting a mixture of this golden bamboo with the black species, *P. nigra*. As a rule, mixtures of bamboos are said to be objectionable, but such a mingling of golden and black stems is worthy of an experiment.

Phyllostachys Aurea, A. & C. Rivière.

(Japanese names: "*Hotei-chiku*," "*Hōrai-Chiku*," or "*Taibo-Chiku*.")

A smaller species than *P. mitis* or *P. quilioi*, but attaining in England a height of 14 feet and a diameter of culm of over three-fourths of an inch. In Japan, culms have been observed over 1½ inches in diameter. It is not a golden bamboo, as its name implies, its stem being about the color of *P. mitis*. The distinguishing characteristic is that the first 5 or 6 internodes near the ground are very short, bringing the internodes, or joints, close together, often only a few inches apart. These joints are not, as in *P. heterocycla*, set at an angle to the direction of the stem, but are generally parallel to each other and quite horizontal. Branch buds are variable in color, but pale. Mr. Mitford remarks that this species should be planted in large, bold masses for good landscape effect, for if single plants are set out they send up shoots only near the mother culm and produce a switch-like effect. The shoots of this species are edible, according to the Japanese books, and are of even better flavor than those of *P. mitis;* but this variety does not appear to be grown for food.

Phyllostachys Bambusoides, Sieb. & Zucc.

(Japanese name: "*Yadake*.")

The arrow bamboo is that of which the stems are still employed in the manufacture of the fine Japanese arrows used generally for archery purposes. The plant is still a rare one in England, and Mitford says that other sorts are sometimes sold by Japanese nurserymen under its name. It is not very commonly seen in gardens, so far as observed even in Japan, and the arrow makers, it is said, get their main supply of stems from wild plants. There are some of these manufacturers in the town of Shizuoka, but the demand for arrows is so small that they are doing a poor business. This species is distinguished from other

y the fact that it does not have an actively creeping rootstock. Each lant forms a separate small clump by itself. The branches are shorter ıan the internodes and the middle branch of the three is longest, hereas in other bamboos the middle branch is the shortest—somenes wanting. Clumps of this form grow to 10 or 12 feet in height Japan, with a diameter of little over three-fourths of an inch. The ternodes are long, and the sheaths, although withering the first year, not fall off until the following year. They are bright green in color, ith a purple edging. The leaves are large, sometimes over 12 inches ng by 1¼ inches broad, and are borne in fours, fives, sevens, or ghts. The hardness of the culms, their small cavity, and the smoothss of the nodes, as well as their small size, are characteristics that ell adapt them for arrow making. This is believed to be a hardy ecies, and it is quite unlike the ordinary bamboos in appearance.

Phyllostachys Marliacea, Mitford.

(Japanese names: "*Shibo-chiku*" or "*Shiwa-chiku.*")

'he "wrinkled bamboo" is easily distinguished from all other kinds the fact that its culms are longitudinally channeled with shallow oves. It is a low-growing species compared with *P. quilioi*, which otherwise resembles, not being commonly over 12 to 14 feet high, n in Japan. It is a rare kind, and its culms are used occasionally, s said, for decorative woodwork in the special rooms which in many ɔanese houses are kept sacred for the tea-drinking ceremony. A ntiful and hardy form.

Arundinaria Japonica, Sieb. & Zucc.

(Japanese name: "*Métaké*" or *Médaké*;" not "*Makode.*")

A well-known bamboo in Europe, where it is not very highly thought by some, but is praised as a valuable decorative plant by others. A m distinguishable by its persistent sheaths which, instead of falling like those of the genus *Phyllostachys*, remain attached until they ome frayed out and split to pieces. These ragged sheaths give to mps of the plant an untidy appearance. The culms are round and hout any groove or flattening on one side, as is the case with the yllostachides. The pseudophylls of the ordinary sheaths are very row, sometimes not over an eighth of an inch wide, and from 1 to 2 hes long; but those of the topmost sheaths develop into true leaves. e leaves themselves are large, 8 to 12 inches by 1½ to 2 inches. s is said to be the hardiest species in Japan, growing as far north the island of Hokkaido, where the temperature falls below zero renheit. Its culms are extensively used for fan making, and lions of cheap paper-colored fans are made every year from the

stems of this species. River banks and the margins of ponds and canals are eminently suited to its growth, and the overflowed lands of the Colorado River in Arizona might be planted to advantage with this species. This bamboo is one of the few that has flowered and fruited in Europe. According to Mr. Mitford, specimens in the Bois de Bologne in Paris, and simultaneously all over France and in Algiers, bloomed and produced fruit in 1867 or 1868.

ARUNDINARIA SIMONI, A. & C. Rivière.

(JAPANESE NAME: "*Narihiradake.*")

This species is easily distinguished by its broad, persistent sheaths of a plain straw color that fall off only after the culms have attained maturity. (Pl. V, fig. 1.) It is the tallest of the hardy arundinarias which are grown in England, the culms attaining a height of 18 feet and a diameter of an inch. The shoots appear from midsummer until late in the autumn, and Mr. Mitford remarks that many do not mature sufficiently to stand the English winters. The sheaths nearest the ground are short, though long enough to overlap the internodes, but those of the upper joints, although 8 to 10 inches long, do not exceed the internodes in length. They are at first of a fine green color, shading into purple, which soon fades, however, to a dull yellow. These prominent sheaths, which are thick, stiff, and beautifully glazed on the side next the culm, will easily distinguish this arundinaria from any other common Japanese form. The species has flowered and fruited in England, and it is quite universally grown in English gardens. A long description of it is given by Mr. Mitford in "The Bamboo Garden."

ARUNDINARIA HINDSII, Munro.

(JAPANESE NAME: "*Kanzan-chiku.*")

The Kanzan-chiku is a very common garden plant about Tokyo, and clumps of it are to be found in many of the farmyards in central Japan, where the culms grow to a height of 18 feet and attain a diameter of over 1½ inches. This species forms pretty clumps, with a fine grass-like foliage, and although little farm use is made of it, it is worthy of trial as an ornamental. Its hardiness has not been demonstrated in England, but it seems likely to prove as hardy as forms like *P. mitis.* It is distinguished from the preceding arundinarias by its long, narrow leaves, sometimes 9 inches by five-eighths of an inch according to Mr. Mitford. The sheath is provided with a reddish margin toward the tip.

ARUNDINARIA HINDSII, var. GRAMINEA.

(JAPANESE NAME: "*Taimin-chiku.*")

A sort similar to the foregoing, but with considerably narrower leaves and a longer, narrower sheath, with no evidences of a brown margin.

BAMBUSA VEITCHII, Carr.

(SYNONYM: *Arundinaria veitchii.* JAPANESE NAME: "*Kokumazasa;*" sometimes only "*Kumazasa.*")

The Kumazasa, by which is generally meant *Bambusa palmata*, and this *B. veitchii* are sometimes confused. The latter may be distinguished by the fact that its leaf margins wither in late autumn and make the plant look as if it were variegated. *B. veitchii* is furthermore, as a rule, only about 2 feet high, whereas *B. palmata* grows to 5 feet in height. The sheath of *B. veitchii* is said by Sir Ernest Satow to be longer and more persistent than that of *B. palmata*. The leaves of *B. veitchii* are much smaller than those of its taller relative and warrant the name of "Kokumazasa," or lesser bamboo. This species is suitable for lawn planting and is used by the Japanese to plant under their pine trees and to cover with a thick mat of green foliage a sloping hillside or embankment, for both of which purposes it is admirably adapted (Pl. V). It must be kept from spreading into cultivated ground by means of a broad ditch, 2 feet deep and 1½ feet wide. The variegated effect produced by the dead margins of the leaves after being touched by frost is striking, though not very attractive.

BAMBUSA PALMATA, Hort. Ex. Kew Bull.

(JAPANESE NAME: "*Kumazasa.*")

A much larger species than the preceding and with leaves 12 to 13 inches long instead of 5 to 6 inches. Altogether one of the most effective plants for embankments, as it covers them with a mass of broad leaf surface which is very attractive. Its rhizomes are said to be good sand-binders. Large patches of this plant on a lawn or hillside are striking objects of interest. Caution must be exercised to prevent the rhizomes from invading cultivated fields. This can be done by ditching, as has been described for *B. veitchii*.

BAMBUSA QUADRANGULARIS, Fenzi.

(JAPANESE NAMES: "*Shiho-chiku*" or "*Shikaku-daké.*")

The square bamboo is unlike any other Japanese species in the possession, when fully grown, of square culms. These square stems are often not apparent on young small shoots, but the older ones are sure

to show this character. The squareness of these culms is aptly compared by Mr. Mitford to the square stems of the Labiates. Small groves of this bamboo are to be seen not far from Yokohama, and the writer has seen stems among one of these groves that were about 20 feet high, while Mr. Mitford says the plant grows to 30 feet near Osaka. The sheath is very thin and delicate and more open than in most bamboos, gaping from the base and leaving the greater part of the internode uncovered. The wood of this species is too weak to make it of any great value, and its sensitiveness to frost is too great to enable one to class it among the hardy sorts. It is, however, a decorative plant and worthy of repeated trials in the frostless regions of America. It is said that roots will form easily from the lower nodes of the square bamboo if the portion bearing these nodes is buried in the soil. This would facilitate propagation if the statement proves correct.

BAMBUSA VULGARIS, Schrad.

(JAPANESE NAME: "*Taisan-chiku.*")

A species growing in Satsuma, the southern province of Japan, but which is not hardy at Yokohama. It is propagated differently from the hardy sorts, as new shoots are borne from the base of the culm as well as from the rhizome. Short culm bases, without rhizomes, are potted and easily transported from Satsuma to Yokohama, where new branches appear from the nodes. This species is said to be easy to propagate because of this character, but it will probably have a chance to succeed in the United States only in subtropical Florida and Texas, where it will require a good soil, rich in humus.

"SHAKUTAN."

"Shakutan" is the name of a very pretty species which is reported to grow in the northern island of Japan and to be perfectly hardy. The writer saw plants under this name in the Yokohama Nursery Company's grounds. They were very distinct from *B. palmata*, and dried specimens were sent to Mr. Makino in Tokyo for determination. The species is probably related to *B. palmata*, but the broad, large leaves are mostly situated near the tip of the slender sheath-covered stem, which rises from the ground with a characteristic curve, and is bare of leaves for several feet from the ground.

Plate V, fig. 3, shows a clump of what appears to be the same species. from Tosa, one of the southern islands of Japan, which was growing in Mr. Tsuboi's garden under the name "Hanchiku." The culms are almost covered with the light-colored persistent sheaths from the ground to the leaves. The stems are not over one-fourth to three-eighths of an inch in diameter, and are about 5 feet high.

PLATES

DESCRIPTION OF PLATES.

PLATE I. A commercial grove of the black bamboo (*Phyllostachys nigra*) growing at Kaiden, Shinkotari, near Kyoto, the property of Mr. Denkichi Fujibayashi. Age unknown, but probably more than 30 years old. Photographed by Yendo.

PLATE II. A well-kept forest of *Phyllostachys quilioi* growing on good soil, showing an open drainage ditch in foreground and the thick mulch of leaves and straw which cover the ground. Age probably over 50 years. Photographed by Yendo.

PLATE III. Bamboo forests. *Fig. 1.*—A well-kept forest of *Phyllostachys quilioi* growing on poor soil filled with gravel Weeding has not been as recently done as in that part of the forest shown in Pl. II. The two photographs from which these plates were prepared were taken from points not 20 yards apart in the forest of Mr. Isuke Tsuboi, of Kusafuka. Photographed by Yendo. *Fig. 2.*—A badly kept forest of timber bamboo (*Phyllostachys quilioi*) growing on good soil adjacent to the well-kept forest shown in Pl. II. This shows the effect of not weeding, thinning out, or fertilizing. Photographed by Yendo.

PLATE IV. Bamboo groves in Japan. *Fig. 1.*—A hillside grove or forest of the edible species (*Phyllostachys mitis*) 20 years old, showing large size of the culms. *Fig. 2.*—A grove of the same species over 100 years old near Tokyo. The bundle of barley straw shown on the right will be used for mulching purposes. *Fig. 3.*—A 12-day-old shoot of *Phyllostachys quilioi* in a forest of the same species on Mr. Tsuboi's place at Kusafuka.

PLATE V. Bamboo groves in Japan. *Fig. 1.*—Clump of *Arundinaria simoni*, showing the persistent characteristic sheaths. *Fig. 2.*—Grove of *Phyllostachys quilioi* on Mr. Tsuboi's place at Kusafuka. Age unknown, but probably more than 50 years old. *Fig. 3.*—Plat of a species of bamboo called by Mr. Tsuboi "Han-chiku," from Tosa Island, which has not been determined botanically so far as known. An exceedingly pretty, decorative form, somewhat like *Phyllostachys palmata*.

PLATE VI. Bamboo plants. *Fig. 1.*—A young black bamboo plant of which the rhizome, to be seen on the left, has died. The rosette of leaves still remains alive, but no young shoots are formed. This specimen was dug in Mr. Tsuboi's garden at Kusafuka. Photographed by Yendo. *Fig. 2.*—Properly dug young plant of black bamboo ready to transplant, showing several inches of rhizome on both sides of the base of the stem, which is necessary for the production of new shoots. This specimen was dug under Mr. Tsuboi's direction and represents his idea of how a plant should be prepared for transplanting if dug late in the season. Photographed by Yendo. *Fig. 3.*—Rhizome or underground stem of bamboo (*Phyllostachys quilioi*), showing young shoots and roots springing from the nodes. Dug in June. If dug in winter, the buds would all be in a dormant condition. Photographed by Yendo.

PLATE VII. Bamboo scenes. *Fig. 1.*—Dwarf bamboos at Kusafuka. *Fig. 2.*—Embankment on top of a wall in a city street in Tokyo planted with *Bambusa veitchii*. *Fig. 3.*—Young shoot showing effects of the bamboo culm-boring larva. Sawdust on outside of shoot affords evidence of presence of larva within. *Fig. 4.*—Longitudinal section of young shoot showing the culm-boring larva inside one of the segments. Photographed by Yendo.

PLATE VIII. Bamboos in California. *Figs. 1 and 3.*—Rows of *Phyllostachys quilioi* (?) growing 25 feet tall in the grounds of a nursery company at Niles. Watered twice a year with 2 inches of water each time. This species is called *Bambusa striata* by Mr. Rock. *Fig. 2.*—Plant of *Phyllostachys quilioi* (?) which was set out two years ago in the grounds of a nursery company at Niles.

WELL-KEPT FOREST OF TIMBER BAMBOO (PHYLLOSTACHYS QUILIOI) ON GOOD SOIL.

FIG. 1.—A WELL-KEPT FOREST OF TIMBER BAMBOO (PHYLLOSTACHYS QUILIOI) ON POOR SOIL.

FIG. 2.—A BADLY KEPT FOREST OF TIMBER BAMBOO (PHYLLOSTACHYS QUILIOI) ON GOOD SOIL.

FIG. 1.—A HILLSIDE FOREST OF EDIBLE BAMBOO, 20 YEARS OLD.

FIG. 2.—A GROVE OF EDIBLE BAMBOO, MORE THAN 100 YEARS OLD.

FIG. 3.—TWELVE-DAY-OLD SHOOT OF PHYLLOSTACHYS QUILIOI IN FOREST.

BAMBOO GROVES IN JAPAN.

Fig. 1.—[illegible] Leaf Sheaths.

Fig. 2.—Grove of Phyllostachys quilioi, Age Unknown.

Fig. 3.—Plot of Species of Bamboo Called [illegible]

BAMBOO GROVES IN JAPAN.

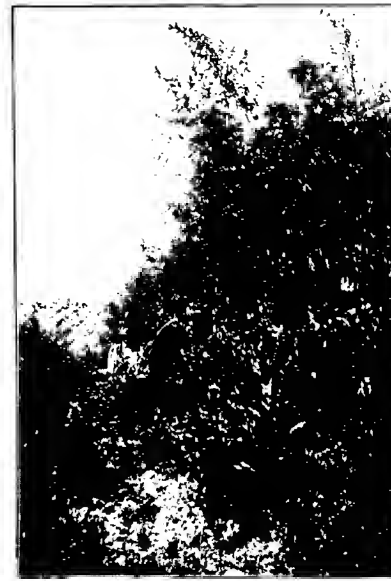
FIG. 1.—BLACK BAMBOO PLANT, SHOWING THE EFFECT OF THE DEATH OF THE RHIZOME.

FIG. 2.—PROPERLY DUG YOUNG PLANT OF BLACK BAMBOO.

FIG. 3. RHIZOME OF BAMBOO WITH YOUNG SHOOTS AND ROOTS SPRINGING FROM NODES.

FIG. 1. PHYLLOSTA ... AT NILES, CAL.

FIG. 2. CLUMP OF PHYLLOSTACHYS QUILIOI THE SECOND ... AFTER TRANSPLANTING.



BAMBOOS IN CALIFORNIA.

Issued June 30, 1911.

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FOREST SERVICE—BULLETIN 95.

HENRY S. GRAVES, Forester.

USES OF COMMERCIAL WOODS OF THE UNITED STATES:

I. CEDARS, CYPRESSES, AND SEQUOIAS.

BY

WILLIAM L. HALL,

ASSISTANT FORESTER,

AND

HU MAXWELL,

EXPERT.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1911

LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Forest Service,
Washington, D. C., April 11, 1911.

Sir: I have the honor to transmit herewith a manuscript entitle "Uses of Commercial Woods of the United States: I. Cedars, Cy presses, and Sequoias," by William L. Hall, Assistant Forester, an Hu Maxwell, Expert, and to recommend its publication as Bulletin of the Forest Service.

Respectfully,

Henry S. Graves,
Forester.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

USES OF COMMERCIAL WOODS OF THE UNITED STATES.

INTRODUCTION.

Our forests have been so extensive, so widely separated, and so full f woods of diverse qualities that we have succeeded in compiling only e most categorical lists of the uses to which the various woods are t. The qualities of our better-known woods are, of course, well derstood by those who handle them, and their properties have been ted by different writers. Their uses, which differ much under fferent conditions, are also recorded, but the records are scattered r and wide in books, Government reports, unpublished lectures and pers, and trade journals. The need has therefore arisen to bring gether in convenient form the available information on the uses of different commercial woods, and this the Forest Service has nned to do in a series of bulletins, of which this is the first. The ies, it is believed, will be of especial interest to lumbermen and se engaged in the wood-using industries, to foresters, and to tructors and students in forest schools.

he material has been collected from many and widely scattered rces, covering the period from the earliest settlement of the coun- to the present time, and embracing all parts of continental United tes. Recourse has been had to books of early exploration and el; industrial histories of regions, localities, and cities; commer- l and trade reports, statistics, and compilations; technical studies rades, crafts, manufacturing, and of expositions; and files of jour- s and periodicals which deal with wood, or the wood-consuming ustries, or with related subjects. Original data collected by the est Service have also been liberally used.

n the arrangement followed each species is considered separately, the attempt has been made correctly to describe the uses made of wood from the earliest times. Present conditions in the wood- uming industries and the multitudes of uses for which the differ- woods have been found suitable have been slowly evolved. No man and no single generation could work out all the uses of a . The pioneer quickly learned which of the scores of woods t him he could best use to supply his special needs, under his al conditions. One by one, as he needed them, he put them into

service, and discovered new ones as his wants increased. The manufacture of wood grew from that beginning, and on that same principle it is growing still, with new uses being added and with other kinds of wood being made available as the need arises.

In order to show the basis upon which the uses of a wood rest, the plan is followed of stating first what is known authentically in regard to the physical properties of each species. This is drawn in part from practical experience of the trades and in part from the investigations of the Government, which have been carried on through a number of years, the first having been made by Sargent in connection with the census of 1880. The later investigations have been carried on by the Forest Service during two distinct periods, the first extending over several years preceding 1897, the last continuing from 1903 to the present time. Sargent's tests covered nearly all the commercial woods of the United States and were made on pieces of the same size and approximately the same moisture content. Although the number of tests for some species was small, it is considered best in this connection to use them, except where the later tests have been made under conditions so similar that the results may safely be compared. For weight, specific gravity, ash, and fuel value the figures of Sargent are as complete and accurate as any later ones, and are here used exclusively.

PHYSICAL PROPERTIES OF WOOD DEFINED.

Since it is necessary in discussing the physical properties of wood to use technical terms, it is proper first to define them and explain as clearly as possible the sense in which they are used.

WEIGHT.

Weight is expressed in terms of a cubic foot of oven-dry wood, calculated from small specimens exposed to a temperature of 100° C. until they cease to lose in weight. While but one value is given, it is the average of a number of specimens, for the variation in weight in the same species is large. This variation could best be shown by giving a range of weights, as some writers have done. Figures showing the range for American woods, however, are wanting, nor does a range of values give any idea of the correct figure to use in calculations. For these reasons it is considered best to give a single figure representing the average of the accurately weighed specimens in Sargent's investigations.

SPECIFIC GRAVITY.

A wood's specific gravity is its dry weight compared with the weight of an equal volume of water at a temperature of 62° F. A cubic foot of water at that temperature weighs 62.355 pounds. If a

cubic foot of wood weighs 30 pounds, its specific gravity is found by dividing 30 by 62.355.

ASH.

When wood is burned until it ceases to lose weight, that which remains is the ash. Its proportion to the dry weight of the wood ranges from one-twelfth or more to considerably less than one one-hundredth. In Sargent's work, the figures of which are here used, an average of the ash of all the specimens taken from the same tree was made, and the average of these averages is given as the final result for the species.

FUEL VALUE.

The fuel values of different woods are fairly well proportioned to their dry weights, with the exception that resinous woods, weight for weight, are higher in fuel value than hardwoods. Sargent's figures are the only ones available, and are used in all cases.

STRENGTH.

The term modulus of rupture is used to express the breaking strength of wood when tested as a beam. It is the measure of a wood's ability to sustain a load. If a beam is supported at the ends and a load is applied at the center and increased until the beam breaks, the load at the breaking would represent its strength. The load stated in pounds per square inch in the cross section of the stick would be its modulus of rupture. Modulus of rupture resulting from a bending test is usually recognized as the best index of the strength of a wood, and on that account is here used. Different woods vary greatly in strength, and specimens from different trees of the same species, or even from the same tree, show wide difference. On this account it is necessary to test many samples, sometimes hundreds, in order to get a reliable average of strength. The modulus of rupture ranges from 5,000 pounds or less per square inch in the weaker woods to 15,000 or more in the stronger. The modulus of rupture of a wood, under average conditions, is approximately equivalent to a load sufficient, if applied to the center, to break a stick 2⅝ inches square, supported on a 12-inch span. For example, if white oak's modulus of rupture is 8,500 pounds, that load would be required to break a white-oak stick of the specified size. In a piece of green wood the moisture content may be as much as 100 per cent of the dry weight, while in air-dry wood the moisture is reduced to 12 or 15 per cent. As the moisture is reduced below 25 or 30 per cent, strength greatly increases. Wood dried to a moisture percentage of 3 or 4 may be three or four times as strong as when green. For

this reason it is important to state the moisture content in giving figures to show a wood's strength. The size of the stick or beam tested has something to do with determining its breaking strength. A small beam is usually stronger in proportion to the area of its cross section than a large one. The apparent difference in favor of the small stick is doubtless due to the smaller proportionate number of defects it contains.

In the recent tests the specimens which furnished the figures here used were clear of knots, 2 by 2 inches in cross section and 30 inches long. In the earlier tests by the Forest Service, the specimens used were 4 by 4 inches in cross section and 60 inches long. The specimens tested by Sargent were 4 centimeters (1.5748 inches) square and 1 meter (39.37 inches) long, and were fully air-dried, as were also the specimens in the earlier tests of the Forest Service. This accounts for the higher values of the woods under those tests compared with the woods tested recently. The latter were often tested more or less green, but the moisture content was accurately determined.

STIFFNESS.

Stiffness is the resistance of a material to deformation under a given load. If a piece of wood 2 by 2 inches and 30 inches long is supported at the ends, and a load is applied at the center, the tendency of the stick to resist bending is its stiffness or elasticity. Suppose that under the load the stick bends one-eighth inch; then if the load is doubled the deflection will be twice as much, or one-fourth inch. If further increases are made in the load, a point is finally reached where more than corresponding deflection results. This point is known as the elastic limit. The measure of stiffness is the modulus of elasticity, which is defined as the measure of the ability of a specimen to resist deformation within its elastic limit.

CHARACTER AND QUALITIES.

Under this heading the attempt is made to sum up in as simple terms as possible the character of the wood and the qualities which form the basis of its utilization. Most of the terms employed are so simple as to require no explanation. Certain of them are used in a restrictive sense which should be noted.

If a wood's weight is less than 30 pounds per cubic foot it is considered light; if between 30 and 40 pounds, medium light or medium heavy; and if over 40 pounds, heavy.

No definite scale of hardness has as yet been arranged for American woods. In fact, tests which might form the basis of such a scale are lacking. It is therefore necessary to resort to indefinite descriptive terms to convey such information as is known.

Grain is here used to designate the structural composition of wood, resulting from the form, size, arrangement, and direction of its component elements of fibers and vessels.[1] According to this usage, grain takes account only of the assembling of the different elements within the layers of annual growth. It does not refer to the width of the annual rings, except as the width or narrowness of these may, to a limited degree, affect characteristically the grain. The component elements of wood have distinctive form and arrangement which vary within limits characteristic of different groups or species. It is these that give character to the grain. If the fibers and vessels which make up a wood are small, the wood is considered fine grained; if relatively large it is coarse grained. When the vessels and fibers are evenly distributed, the condition is described as even grained, while the opposite condition would be uneven grained. Where the direction of the elements is parallel to the axis of the tree, the wood is called straight grained; when they interlock and are not constant in one general direction, we express the condition as cross grained. Again, if they assume a wavy or curly condition, we accordingly designate the wood as wavy or curly grained. In many trees the elements run spirally around the axis, in which case it is proper to speak of the wood as spiral grained.

This usage in designating the grain of wood differs somewhat from the popular conception, but the word as popularly used lacks constant meaning. Sometimes it refers to the above-named properties, sometimes to rings of annual growth, and again to medullary rays and even to hardness. Often it is used without specific meaning and refers loosely to all of these things.

While grain manifestly should not refer to the rings of annual growth, it is fundamentally influenced by the bands of spring and summer wood which make up the rings, since those bands result from the different association of the elements. Also, grain may be considered as being influenced by the medullary rays, since these, too, present a characteristic form and association of elements. It is necessary, however, to describe these characters specifically, as the terms mentioned above do not adequately designate them.

While grain is only properly described by the use of terms such as those defined, it is entirely natural that the woodworker should base his descriptive terms upon the qualtities which are most important to him. To the handle worker smoothness is an essential quality, and he usually finds it in a fine-grained hard wood, such as hickory, pear, or maple. It is perfectly natural for him to judge a wood not by its fineness, but by the smoothness with which he can cut and polish

[1] For the basis of this definition and for the discussion of grain which follows, the authors are indebted in large degree to Mr. George B. Sudworth and Mr. C. D. Mell, of the Forest Service.

its surface. The pattern maker judges a wood by the ease and evenness with which his tools will cut it, both with and across the grain. His idea of grain is associated with the way in which the wood cuts. The furniture maker's idea of grain goes further than that of the handle maker or the pattern maker. He takes into account the wood's appearance when it is cut in either tangential or radial section, or oblique to the radius. On account of the prominently developed medullary rays in woods such as the oaks, quarter sawing is resorted to in order to enhance the appearance of the resulting surface by exposing to view streaks or patches of the bright, smooth rays. Consequently, the medullary rays frequently become an important factor in the furniture maker's idea of grain. Such surface characters are perhaps better designated as figure.

In color, woods range from white, as in the case of holly, to very black, as in ebony, with practically all intermediate colors and tints. Enough of the coloring matter of some woods—redwood for example—may be worked out with water to impart color to the water. The color of others can be removed only by chemical action, and then only to a small extent unless the wood is first reduced to pulp. Unless otherwise stated, the color refers always to that of a fresh cross section of a piece of dry wood. In certain woods, such as black walnut, mahogany, and redwood, color is a most valuable quality. In others the lack of color is prized. This is especially true of woods used for pulp.

By durability is meant the resistance of wood to decay under conditions favorable to the growth of decay-producing fungi. In order for the fungi to operate, there must be a food supply, air, moisture, and heat. Under constant extreme conditions of moisture or dryness decay does not take place. Wooden coffins in the Egyptian tombs, which have remained perpetually dry, have lasted for ages; so have logs in the swamps which have remained constantly wet. That a wood has not decayed under such conditions is nothing in its favor. Decay simply has no opportunity to take place. Under the dry conditions it was prevented by lack of moisture, and under the wet by lack of oxygen. Between the extreme conditions of constantly wet and constantly dry, decay may take place. One set of conditions may be very much more favorable for decay than another. We can not, on that account, accurately compare the durability of two woods in different localities or under different conditions. They must be side by side and subjected to the same conditions. Certain of our woods are noted for their durability. Before they can be arranged in order, however, they must be tested under the same conditions, and this has not yet been done. It is impossible, therefore, to refer woods to a definite scale in discussing their durability. We can only state with considerable indefiniteness whether they rank among the durable ones or among those which do not resist decay.

GROWTH.

The growth of a tree, as the term is here used, means its average size at maturity attained within its commercial range under ordinary conditions.

THE CEDARS.

Every region of the United States produces one or more species of cedar in sufficient quantity to be of use. Considered as a source of lumber and wood supply, the more important are:

Southern white cedar (*Chamæcyparis thyoides*).
Northern white cedar (*Thuja occidentalis*).
Red cedar (*Juniperus virginiana*).
Western juniper (*Juniperus occidentalis*).
Incense cedar (*Libocedrus decurrens*).
Port Orford cedar (*Chamæcyparis lawsoniana*).
Yellow cedar (*Chamæcyparis nootkatensis*).
Western red cedar (*Thuja plicata*).

A few other species contribute to the lumber supply in different regions, but not to a large extent. Broadly defined boundaries may be described for each of the cedars, although the commercial ranges occasionally overlap. The northern white cedar reaches its best development in the Lake States; the southern white cedar near the Atlantic coast between New York and Florida. The red cedar ranges over the eastern half of the United States, but the most valuable cut now comes from States south of the Ohio River. Western juniper and closely related species are found from the northwest Rocky Mountain region to the Pacific coast. Incense cedar is cut in California and Port Orford cedar in southwestern Oregon. Yellow cedar and western red cedar reach their best development in Oregon and Washington, but their commercial range extends to southern Alaska.

Although the eight species here given botanically represent four genera, all are more or less commonly known by lumbermen as cedars. This is doubtless due to the general similarity of appearance of the growing trees, to the numerous common characteristics of their wood, and to the similar uses to which they are adapted. In statistical reports all of these woods are grouped under the name of cedar. In published statistics one species can be distinguished from another only by the region from which it comes. This is not a safe guide. Red cedar and southern white cedar, for example, occupy in part the same territory, and the same chance for confusion exists with the western red cedar and the yellow cedar, and others. If one can examine the wood, however, there is less danger of confusion, as some species are entirely distinct, and all can usually be readily distinguished.

Southern White Cedar.

(Chamaecyparis thyoides.)

PHYSICAL PROPERTIES.

Weight of dry wood.—20.7 pounds per cubic foot. (Sargent.)

Specific gravity.—0.33. (Sargent.)

Ash.—0.33 per cent weight of dry wood. (Sargent.)

Fuel value.—44 per cent that of white oak. (Sargent.)

Breaking strength (modulus of rupture).—6,300 pounds per square inch on pieces 4 by 4 by 60 inches, with 12 per cent of moisture. (Forest Service Circular 15.)

Factor of stiffness (modulus of elasticity).—910,000 pounds per square inch. (Forest Service Circular 15.)

Character and qualities.—Very light, soft, comparatively weak; grain fine, even, and straight; compact; annual rings narrow as a result of slow growth; summerwood thin, dark-colored, conspicuous; medullary rays numerous, obscure; color light brown, tinged with red, growing darker with exposure, the sapwood lighter; easily worked; very durable in contact with the ground.

Growth.—Height 75 to 80 feet; diameter 2 to 4 feet, though latter is exceptional.

SUPPLY.

Twelve or more States contribute to the supply of white cedar, but the annual cut is not known, because this species is not listed separately, but goes to the market with half a dozen other species under the common name of cedar. The States which furnish most of the supply are Delaware, Florida, Georgia, Maryland, New Jersey, North Carolina, South Carolina, and Virginia.

The cut of all woods listed as cedar in the United States in 1907 was 250,000,000 feet, exclusive of poles and ties; but certainly less than one-sixth of this was southern white cedar. Sixty-three per cent of all the telegraph and telephone poles purchased that year in the United States were cedar, but again the proportion that should be credited to southern white cedar is not known.

The value of southern white cedar for many purposes is so well understood that the demand is heavy, and the annual cut greatly exceeds the growth. This is apparent in a general survey of the country and the lumber operations, but exact figures showing remaining stands are as hard to obtain as those which show the yearly cut. It is certain, however, that the remaining supply is very small in comparison with the original stands in the forests which fringed the Atlantic coast from Maine to Florida and westward near the Gulf to Mississippi.

In some particulars southern white cedar has been more fortunate than most commercial timbers in the eastern part of the United States. Less of it has been wantonly destroyed, or cut and burned to make room for agricultural crops. This was because it grew on land too wet for the plow, and under most conditions too wet for forest fires. There was little cutting of white cedar to make room for the garden and cornfield of the settlers. The untillable and frequently impenetrable swamps where it grew protected it. Not even the cypress could compete with it for the possession of water-soaked morasses.[1]

The cutting of this cedar began probably 300 years ago and was in full blast in New Jersey two centuries ago. It was drawn upon for supplies all the way from New England to Florida, but New Jersey has always been a center for its lumber, and the quantity drawn from the swamps of that State, first and last, has been very large. Nearly 200 years ago John Lawson listed its uses in the Carolinas as "Yards, topmast, booms, and bowsprits for boats, and shingles and pails." More than 160 years ago the drain had become so great that fears of exhaustion of supply were freely expressed. Gottleib Mittelberger then declared that at the rate of use in his time the end was in sight; and Benjamin Franklin published an essay in which he advocated forestry methods, especially the planting of red cedar to supply the country when the white cedar and other woods should fail.[2] A year or two later Peter Kalm, a Swedish naturalist traveling in America, foretold the inadequacy of the white cedar forests to meet demands in the near future. Seventy years after that time, however, William Cobbett, an English traveler, declared, but with evident exaggeration, that "all the good houses in the United States" were covered with white cedar shingles.

Southern white cedar is in the peculiar class with mesquite in that a considerable part of the timber comes from beneath the surface of the ground. About 100 years ago the mining of white cedar logs began in New Jersey, and is still in progress. Forests that flourished centuries ago fell in the swamps where they grew and the trunks sank beneath the water and mire. Many of them decayed but little or not at all, and when brought to the surface were found fit for shingles or lumber. Trunks 6 feet in diameter were occasionally found, and the position of some trunks under many superimposed trees and roots indicated that they had lain submerged during many centuries.

White cedar does not promise great things for the future. It can never be extensively and profitably planted, because its range has been pretty definitely fixed by nature to the deep swamps and miry marshes near the coast. Within these bounds, however, it may con-

[1] "The North American Sylva"—A. B. Michaux and Thomas Nuttall.
[2] Poor Richard's Almanack, 1749.

tinue for a long time to be of some importance. In some of the swamps where it is found little else that is profitable to man will grow. Such swamps might be kept perpetually in cedar, though the trees grow slowly. Crop after crop of some other trees may be planted and harvested elsewhere, while a single stand of white cedar attains even respectable pole size. Fifty years may be required to produce a fence post. A swamp in New Jersey in which all the timber was killed required half a century to grow posts from seed. It may be expected, however, that supplies will be got for years from southern and eastern swamps, but the quantity and quality harvested in early years need not be looked for again. Rather than be kept for cedar production it is far more likely that the next few decades will see the eastern swamps drained and turned to the production of agricultural crops.

EARLY USES.

The first general use to which this cedar was put was for fences, houses, and farm buildings. Many of the earliest houses in New Jersey, and some in eastern Pennsylvania, were constructed almost wholly of this wood. In making rails of it, farmers preferred trees which would split two, three, or four rails to the cut. The bark was removed, and the rails sometimes gave service extending over half a century. The cost of such rails in the middle of the eighteenth century was from $6 to $8 a hundred. Log houses and barns, and other buildings of the farm, were made of this cedar while it was abundant, but such extravagant use had become infrequent in 1750, and logs had given way to sawed lumber for building purposes. For a long time after that many houses were built wholly or in part of this wood, even as far south as North Carolina. It was taken, on account of its durability, for floors, doors, frames, joists, rafters, but especially for shingles. These were made from 24 to 27 inches long, and while prices varied greatly in different localities, quotations from Baltimore, where they were known as juniper shingles, about 1800, were $4 and $5 per thousand. In 1750 the architects of Philadelphia were criticized because the houses in that city had been designed for white cedar roofs exclusively, and the walls were too slight to sustain roofs of heavier material when a new covering should become necessary and white cedar could not be obtained. Philadelphia was not alone in its preference for roofs of this light wood. Large shipments of cedar shingles went from New Jersey to New York even before 1750, and from that time on all the towns and cities within the range of this timber drew shipments of shingles as well. Some foreign markets had to be supplied also, for at the time when complaint was heard that the white cedar forests were failing daily cargoes of the shingles were going to the West Indies, which also took considerable quantities of white cedar pipe staves.

Southern white cedar was one of the first, if not the first, of American woods used in the construction of pipe organs. A German organ builder, Gottleib Mittelberger, who has been previously quoted, observed when he reached Philadelphia that the patter of rain on the white cedar roofs made sounds highly musical to his ear, "like a roof of copper or brass," and he tried the wood for pipes in his organ work. He declared that the tones emitted by the cedar pipes were finer than from metal. The wood received high praise at an early date as sounding boards in pianos, but it does not seem to have held its ground in competition with spruce.

Next after fences, building material, and shingles, the most important early use of southern white cedar was in cooperage. In some ways it was more important than the others, though the quantity of wood used must have been much smaller. In the vicinity of Philadelphia a special class of tradesmen grew up, known as "cedar coopers," because they wrought this wood exclusively and supplied an extensive and exclusive trade with their wares. Oil merchants were prejudiced in favor of tanks of white cedar for whale oil, and for other oils also, and bought liberally. But the chief trade was in churns, pails, firkins, keelers, piggins, and washtubs. The popularity of that class of wares was due, first, to their excellent quality, but largely to their fine appearance. Wear and use made them smooth and white, and it was supposed that they were more easily kept clean. Another thing which increased their popularity was the common belief that the wood possessed medicinal properties and imparted them to the contents of the vessel. It was even believed that water issuing from a white cedar spigot had its healthfulness increased.

The hoops for the cedar ware were of the same material and were made from saplings from the smallest size up to 2 inches in diameter and 12 feet long. Coopers paid from \$5 to \$12 a thousand for them. The sale for the special line of wares extended in a limited degree to foreign countries.

MANUFACTURE AND PRODUCTS.

Nearly all the early uses of white cedar have continued till the present, but with much change in the proportionate quantities employed for the various purposes. Fewer fence rails and smaller amounts of rough construction lumber are in use now than formerly, but new uses take more. Telephone and telegraph poles are a modern demand that is heavy. Paving blocks have drawn from this source to a moderate extent. Railroads use rather largely of this wood for posts in fencing their tracks, and they use heavy logs for culvert work. A demand has to be met for piling for wharfs, trestles, bridges, and causeways. Southern white cedar ties go into tracks in large numbers, though some that are listed as this species are really the northern white cedar from the Lake States. It lasts well so far

as decay is concerned, but does not wear well because too soft. Its place is chiefly in trolley roads, where traffic is light, and there it gives good service. Farmers use large numbers of fence posts of this wood, and vineyardists employ it for stakes.

In the building of canoes, skiffs, and small boats, lightness is often a chief requisite, and white cedar is an ideal wood. It answers well as interior finish for yachts and launches; and for similar reasons it is employed by carpenters as house finish. Its light and cheerful color gives a cool, airy appearance to halls and stairways in summer cottages, and by some it is preferred to white pine. It is given place in more pretentious architecture for porch posts and piazza columns. It is made into wedges by makers of furniture and cabinets, and it gives good service in tennis rackets.

Cigar-box makers use white cedar, and some of it goes to the toymaker's shop and to the novelty factory.

BY-PRODUCTS.

A not inconsiderable part of the fighting by which the Revolutionary War was brought to a successful close was done with gunpowder made of white-cedar charcoal. The best results in burning charcoal for that use is had with limbs and sticks not exceeding 1½ inches in diameter.

Lampblack of excellent quality is made of it, and was so made a century ago. The article, when manufactured from seasoned wood, is lighter in weight and deeper in color than the lampblack made from pine.

This cedar has a strong aromatic odor which remains as long as the wood is kept free from moisture, but it largely disappears from wet wood. It does not entirely vanish, however, if the testimony of the men who dig the logs from the New Jersey swamps may be taken. They claim to be able to determine from the odor of a chip cut from a submerged log whether the tree seasoned in the air, or was submerged in its green state, and whether the log will be worth digging out.

Living white cedar trees exude a gum from wounds in the wood but the quantity is small and its commercial value doubtful.

NORTHERN WHITE CEDAR.

(*Thuja occidentalis.*)

PHYSICAL PROPERTIES.

Weight of dry wood.—19.7 pounds per cubic foot. (Sargent.)
Specific gravity.—0.32. (Sargent.)
Ash.—0.37 per cent of dry weight of wood. (Sargent.)
Fuel value.—42 per cent that of white oak. (Sargent.)

Breaking strength (modulus of rupture).—7,200 pounds per square nch, or 55 per cent that of white oak. (Sargent.)

Factor of stiffness (modulus of elasticity).—750,000 pounds per quare inch, or 36 per cent that of white oak. (Sargent.)

Character and qualities.—Very light, soft, comparatively weak, rittle; grain fine, even, and straight; compact, annual rings, narrow; ummerwood very thin, dark colored; medullary rays numerous, ndistinct; color light brown, turning darker with exposure, the thin apwood nearly white; easily worked; sapwood not very durable, but eartwood of remarkable durability.

Growth.—Height 50 to 80 feet, diameter 2 to 4 feet.

SUPPLY.

The chief supply of northern white cedar comes from the Lake States, though a little is cut in perhaps a dozen other States. As ith southern white cedar, it is impossible to determine how much f the total cedar cut is of this species. In some instances, however, e locality will help to determine. The equivalent of 20,000,000 et of cedar lumber, lath, and shingles was cut in the Lake States 1907, and the principal part of it was of this species. In addi- on to this there were cut in the same region 13,000,000 posts from to 16 feet long, and more than 3,000,000 poles 18 feet or more in ngth. Estimates of the quantity of northern white cedar yet avail- ble in the region have not been made, but it is not believed that nything like complete exhaustion of the supply is near. In addition posts, poles, lumber, and shingles, this wood supplies many rail- ay crossties. It is too soft to stand excessive traffic, and ties to give ng service beneath heavy trains must be protected by plates. They nswer the needs of street railways well.

The supply for the future, as far as it can now be foreseen, will me from natural reproduction in swamps and in rugged regions, nd not from planting. The tree thrives in situations where many her trees can not maintain themselves. It is at home in the north- n swamps, while among the mountains it accepts a foothold on cky slopes, steep banks, and along the summits and against the ces of cliffs.

USES.

The Indians in the north country sometimes made frames of this dar for their bark canoes. The wood was lighter than any other at the Indians could put to that use, and that was doubtless a factor its favor. A few pounds saved in the frame of a canoe meant uch to those who expected to carry the vessel across portages and

frequently long distances through forests. The facility with which the wood might be split along the rings of annual growth appealed to the native canoe makers, whose wood-working tools were few and crude. The wood is still used by makers of small boats.

Northern white cedar logs were sometimes, though perhaps not frequently, used in house building. Trees of this species that grow in swamps, and those on river banks and precipices, nearly always have curved trunks which rise from the ground in the form of arcs or ellipses. For that reason they can not be conveniently fitted in house walls. Where better could not be had, however, this tree was pressed into service; and it is recorded of a mission house of this wood at Lake Chicoutome that it was erected in 1728, and in 1792 the logs were sound.[1]

This wood is not often used by carpenters, partly because it is not commonly sawed into lumber, and for the further reason that the softness of the wood renders it incapable of holding nails in positions subject to strain. It is admirably suited, however, for certain kinds of cooperage, where lightness is desirable, resistance to decay a factor, and great strength not essential. It finds such a use for buckets, tubs, pails, and various kinds of small wares. It is important also as a tank material, and for that purpose not the least of its good qualities is its long resistance to decay. Its use has been reported for cigar boxes and in the manufacture of store fixtures.

The northern white cedar is preeminently a fence material in the regions where it abounds, and it is employed for fences of various kinds, some of stakes and small branches crossed and interwoven, others of poles and rails, and still others of posts and boards. Upward of 300,000 posts of this wood were reported to have been used in Iowa in 1908. Used as a fence post, it lasts from 10 to 40 years. The average life in Iowa is reported to be 12 years. In all situations it ranks among the durable post timbers. An instance is recorded of a log that had lain on the ground 130 years and was still sound enough for shingles.

This wood has been extensively used for paving blocks, which in many instances were not given preservative treatment to lessen decay. In 1910 untreated blocks were taken up at Evanston, Ill., after 1[illegible] years of service, and though decay was far advanced, the wood was worth something as fuel, and much of it was so used. In 18[illegible] Chicago had 765 miles of untreated block pavement of this wood, and continued to put it down until 1903. It was gradually replaced by other materials, and on December 31, 1909, there remained in the city only 396.9 miles of the pavement. Replacement with other pavement was then going on at the rate of 50 miles a year. In most instances deterioration was due more to the method of laying than t[illegible]

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[1] Michaux's Sylva.

ecay or wear. Pavement of this wood was nearly always made of ound blocks about 6 inches high, cut from trees from 5 to 10 inches ı diameter. Many cities and towns in the Lake States and adjacent egions, both in Canada and the United States, put down large uantities of this pavement from 20 to 25 years ago.

Much bored and banded pipe for water mains was formerly made f this wood, and some is still made.

The early settlers of eastern Pennsylvania and New Jersey made rheumatism ointment by bruising the leaves of the tree and molding em with lard. Modern pharmacists distill an oil from twigs nd wood and make a tincture of the leaves, which they use in the anufacture of pulmonary and other medicines.

Brooms are made of the small and pliant branches of the cedar, and hen used to sweep floors they leave a pleasant and characteristic dor. There is considerable demand for such brooms in bungalows nd summer resorts in the Lake States region, where the wood may e easily procured.

Red Cedar.

(Juniperus virginiana.)

PHYSICAL PROPERTIES.

Dry weight of wood.—30.7 pounds per cubic foot. (Sargent.)

Specific gravity.—0.49. (Sargent.)

Ash.—0.13 per cent of dry weight of wood. (Sargent.)

Fuel value.—66 per cent that of white oak. (Sargent.)

Breaking strength (modulus of rupture).—10,400 pounds per uare inch, or 80 per cent that of white oak. (Sargent.)

Factor of stiffness (modulus of elasticity).—940,000 pounds per uare inch, or 45 per cent that of white oak. (Sargent.)

Character and qualities.—Medium light, soft, not strong, brittle; ain fine, even, and straight, except as interfered with by knots; nual rings narrow to medium wide, compact; summerwood narrow d indistinct; medullary rays numerous, very obscure; color dull sometimes bright red, the thin sapwood nearly white, heart and p sometimes intermingled; easily worked as a result of softness and enness of texture; heartwood considered as durable as any other nerican wood.

Growth.—In some parts of its range the red cedar attains a height 80 to 90 feet and an extreme diameter of 4 feet, but in most regions ere it is found it does not often exceed half of that size.

SUPPLY.

The commercial range of red cedar is difficult to define. Its botani- range is very wide, and wherever it grows it is put to some use. present the chief supply in the market comes from the region

between the Ohio River and the Gulf of Mexico. It is found from Maine to Minnesota and southwest to Texas, and south and east of those lines.

Southern red juniper (*Juniperus barbadensis*) so closely resembles red cedar that the two were long considered identical. It grows in South Carolina, Georgia, Florida, and the Gulf region westward. Its uses are and have always been similar to those of red cedar.

Red cedar was never abundant in the same degree as white pine, yellow pine, or white oak. Numerous other woods probably once surpassed it in quantity; yet a great deal of it was found when early settlements began on the Atlantic coast and pushed inland to the Mississippi Valley. How many feet of it there were at first can not be estimated. The best of it was gone before it occurred to anyone to make estimates and express figures in feet. One hundred and sixty years ago Peter Kalm and Benjamin Franklin, basing their predictions on independent investigations, announced that red cedar could not long continue to meet demands upon it. But these predictions took account only of the cedar of New Jersey, Pennsylvania, and New York. The extensive forests of the South Atlantic States and particularly those west of the Allegheny Mountains in Kentucky and Tennessee, where the finest red cedar grew, were little known at that time. New Jersey was then supplying, and for many years has supplied, the bulk of the red cedar used at home and abroad. The total quantity before cutting began could certainly have been measured only by hundreds of millions of feet, but a closer approximation can not now be made. Anything like a careful estimate for a large region of standing timber was not made until recently, when figures were compiled for Kentucky. The total stand of cedar there, practically all of it red cedar, was placed at 29,534,000 feet.

The best was culled and cut years ago. As supplies ran short in districts convenient to market, lumbermen pushed farther back in search for more. As late as 1900 from 2,000,000 to 3,000,000 feet of good cedar was rafted down the Cumberland River from the vicinity of Lebanon, Tenn. It is not believed that another such lot will ever be, or can ever be, collected in any locality. Every cedar region has been explored, and choice trees are few. Tracts cut over once or twice before are frequently logged again, and wood is taken which was rejected previously. The search for cedar is even more industriously prosecuted than is the search for black walnut. Comparatively large quantities are still collected, but the grade is lower because choice logs in large numbers no longer exist. It is not unusual to haul logs 20 miles on wagons over rough mountain roads to deliver them at a railroad station or on the bank of a navigable stream. Such long and expensive hauls are made chiefly to procure pencil wood.

The red cedar, considered as a species, is remarkably tenacious of fe. It is hard to exterminate. It has been called a "vagabond ree," because of its habit of living in almost any and all sorts of laces—in old fields, along fence rows, in stone heaps, among swamps, 1 poor soil and fertile, in upland and valley. Red cedar is one of he most common trees found on old abandoned fields from New England to the Southern States. Its roots draw sustenance from soil inches deep, spread over solid rock. The fact that few other trees an do this gives red cedar a sort of monopoly of such situations. he best wood is not produced under circumstances so unfavorable, ut all cedar that attains size for poles and posts is good for someing: and all kinds of places contribute to the total supply. The etter the soil the better the quality of wood.

The red cedar's habit of early seed bearing also aids in keeping p the supply; for as soon as a tree attains an age of 10 or 12 years bears berries. These ripen the second year, and birds, or chance, running water distribute them. The seeds of many soft woods e winged, and travel on the wind; but red cedar is less fortute. Yet, its seeds find lodgment in all sorts of favorable and nfavorable places, and when they once take root, the soil and cirmstances must be exceedingly unfavorable if a post, pole, or w log does not finally result. The tree's worst enemy is fire. he thin bark is easily burned through, bringing death; or the ots, which nearly always lie near the surface of the ground, are orched, with fatal result. Few young cedars survive a brisk fort fire.

In 1749 Benjamin Franklin published in "Poor Richard's Almack" an essay on the uses, planting, and management of red cedar eastern Pennsylvania and in New Jersey. At that time little was own of the cedar resources of the South and Southwest. It does t appear that Franklin's advice to plant red cedar was extensively ed upon. In part he said:

By a diligent observation in our provinces, and several adjacent, I apprehend t timber will soon be very much destroyed, occasioned in part by the nesity that our farmers have to clear the greatest part of their land for tillage pasture, and partly for fuel and fencing. The greatest quantity of our ber for fencing is oak, which is long in growing to maturity, and at best f short duration; therefore, I believe it would be to our advantage to envor to raise some other kind of timber that will grow faster or come sooner aturity and continue longer before it decays.

e red cedar (a species of juniper) I take to be the most profitable tree for ing and several other uses that we can raise in our country, considering easily it may be raised from seed, its readiness to grow on most kinds of its quick growth, the profits it will afford while it is arriving at maturity, the long duration of the wood when grown to a proper size for the materials rant for our several occasions in husbandry and building. I know of no r tree that will grow so well on such different soils as this will, for upon

our sandy beaches, which are nothing but beds of sand, they grow as thick as possible, from whence many thousand posts for fencing are brought into Pennsylvania and York governments; and I have seen, in a great miry swamp upon a branch of Susquehannah, great trees growing, near 18 inches diameter, [illegible] feet high, and very straight. And the inhabitants near the mountains, up Hudson River, make great use of them for making large hovels or barracks to put their corn in before it is thrashed. They will grow well in high gravelly or clay soil, in rich or poor, or even upon a rock, if there be but half a foot of land or earth upon it. It is much to be valued for its quick growth from seed, the little sap, and its much durable heart, which it acquireth sooner than any tree that we can raise on common land. Indeed, the mulberry and locust are of quick growth in very rich land, but not upon poor. A cedar tree, from the berry, will in 8 years be fit for hoops, in 10 for bean poles, in 12 for hop poles, in 16 or 18 for ladders, and in 20 will be big enough to make three posts, besides a good stake at top; with this care, that they are not removed, bruised, or broken, which very much retards their growth, makes them deformed, and spoils their straight, pyramidal growth, which form this tree naturally inclines to grow to more than most trees, and in which we must enjoy the greatest profit from it. And we may in this assist nature by art in carefully trimming them every three or four years, cutting the branches close and smooth off to the bole, so that these wounds may soon be closed, which will make the tree smooth on the surface and the grain straight, which will be of great service if we make boards or rails of them, which will be much the better for being clear of knots. But if we let this tree grow without trimming, as it naturally shoots out branches on all sides in all the degrees of its growth, the lower ones die, but do not rot off near the boles, as in other trees, so that the sap can't close over them, but grows round, which makes the grain crooked, and instead of being straight and even it appears as if drove full of spikes, as we may observe by the posts (especially the second cut) that are brought from the seacoast, where they grow naturally though not so large or tall as these beyond our northern mountains. It is now generally used for posts, which, as I am informed, will last 50 years or longer so that one set of these posts about a plantation would last a mature age, which would be a great advantage to farmers, and at the first cost, with white cedar or chestnut rails, would be no dearer than a quick-set hedge and ditch, which must be often repaired. This wood would be of extraordinary service in building, for sills, and for door and window cases, and boards for floors—I suppose one of the best woods, as not being subject to swell with moisture or shrink with dryness, whether or not it would be very good to make large cisterns for the malters to steep barley in and for the brewers for coolers. I have seen sloops a building at Albany of this wood; indeed, the bottom, as I remember, was made of oak, for as the river there is shallow, and the vessels often strike upon sand or gravel, which oak, as being a stronger wood, is better able to bear such a shock than cedar, which is more tender, yet notwithstanding the Bermudians build fine, durable vessels thereof; and I have seen cedar trees growing in Pennsylvania large enough to make wider planks than any I have seen in a Burmuda-built vessel. I believe it would make curious lasting boats, which would swim light, row well, and want but little repairs for many years. I don't doubt but that my countrymen will think, if not say, What signifies telling us of such great advantages which we can't obtain? We don't know how to get either hoop or bean poles of cedar, much less trees for house or ship building. But I am of opinion that with care, ingenuity, and industry we may make the very raising of them to a proper magnitude (exclusive of the value of them when cut down) to be easy, ornamental, and profitable.

EARLY USES.

A smaller quantity of red cedar has been used for fuel than of any other abundant tree in an extensive region. One of the earliest observations by New England writers was the fact that Indians never burned this wood in their camp fires. It burns slowly and with little blaze. It answered very well, however, for charcoal, and was put to some use for that purpose.

The usual form and manner of growth of red cedar lessen its use for lumber. It is occasionally sawed into boards, and always has been, but a red cedar saw log is apt to be an unprofitable stick from the millman's viewpoint. Many trunks are disfigured with longitudinal ridges and deep clefts between them. Thick slabs must be cut off before such logs can be squared, and the waste is large. This peculiarity has always had much to do with lessening the use of red cedar as saw timber, although instances are not wanting where very large and perfect timbers have been cut. The ridges are supposed to result from large limbs, living or dead. The limbs persist long after they become dead and dry, and after the period when most trees would shed them. The result is very knotty lumber. Red cedar justly has the reputation of being among the knottiest woods that go to the lumber yard. When used in round sticks for posts, poles, piles, and stakes, the knots are not a serious defect. Benjamin Franklin suggested in 1749, and Michaux seconded the suggestion 60 years later, that owners of red cedar prune the young and growing trees two-thirds of the way up the bole to lessen the knots when the trees reached saw-log size.

Red cedar was early an important fence material in all regions where it was plentiful. In the South it was often split into rails, and thousands of acres were inclosed with it. North of Maryland mention of red-cedar fence rails is seldom found in early writings, but posts of that wood were very common. In some instances posts of red cedar were mortised for the insertion of white cedar rails, or boards, or rails of chestnut or oak. It was the enormous number of posts employed by Pennsylvania and New Jersey farmers which called from Peter Kalm, in 1750, the prediction that red-cedar forests would cease to exist in 50 years. In Virginia, and probably elsewhere in the South, a kind of hedge fence was made of cedar, which was planted in rows, with the side branches kept clean cut. The remaining limbs were interwoven, and strengthened with stakes when necessary, and a strong living fence was made. Fences of cedar pickets were likewise common, and the wood's resistance to decay gave such fences a long period of usefulness.

In all parts of the red cedar's range it was early put to use in building houses, barns, corncribs, mills, and other kinds of rural structures.

This use was more common in the South than in the North, and was greatest in Tennessee, by some regarded as the region where red cedar reaches its highest development. It has been said that half of the pioneer cabins in Tennessee were of this wood; but the high estimate probably applies only to particular localities. It is certain, however, that it was a popular and much-used building wood in that region. Thousands of houses were covered with shingles made of it, and an extreme period of usefulness, covering 80 years, has been claimed for some of the roofs. It was cut for flooring for residences, barns, granaries, and mills. Heavy cedar puncheons forming porch floors have been found clear and sound after the generation of builders had passed away. Rude cabins in remote localities had joists and rafters of solid cedar that would have done credit to Solomon's Temple.

Early millwrights knew the lasting qualities of red cedar, and used it in rural mills, where in many cases it survived the builders. The hewed and sawed planks and beams made frames, penstocks, forebays, trunks, bulkheads, and dams.

A century ago in Philadelphia red cedar barriers on the sidewalks were 8 inches in diameter and 10 or 11 feet long, and cost 80 cents each. Other fairly good timbers could have been had at that time for one-fourth or one-fifth of that price, but the excellent service which red cedar gave caused its employment regardless of cost.

Red-cedar staves were among the earliest American exports to the West Indies. A larger demand upon the wood was made for home use, for few houses within the regions where the tree was abundant were without their cedar wares, consisting of pails, buckets, tubs, tanks, and all kinds of small wares made of staves. Well buckets were frequently of red cedar when almost any other wood was available. They usually wore out before decay rendered them unserviceable. A red cedar bucket with brass hoops that was made in Tennessee in 1767 was exhibited at the St. Louis World's Fair. The wood was still sound and the hoops bright. Sometimes the red heartwood and the white sapwood were used alternately in cooperage, and this pattern is still in use.

Coffins of red cedar were common in the South, and were occasionally seen in other parts of the country. It was not unusual for the boxes in which coffins were placed to be of the same material.

Red-cedar furniture was among the earliest products of the eastern part of the United States. It was seen in Virginia as early as 16 and in 1714 John Lawson wrote of such furniture in North and South Carolina, and also of the wood's use in house and ship building in the South. He said it was reputed to be comparatively immune from attacks of marine borers. The Indians of the Carolinas frequently roofed their huts with its bark, and the Ohio Indians made purple

dye from its roots. Among the articles for which it was specially recommended were clothes chests and wardrobes. Its chief virtue, like that ascribed by the early Virginians to sassafras wood, was declared to be its odor, which kept away moths and bugs. Before settlements had advanced 50 miles inland from the coast, red-cedar chests were a well-known commodity, and a very old list of cedar furniture refers to "nests or chests, sweet and fine bedsteads, tables, desks, lutes, virginals, and many things else."[1] The use of such chests has continued during nearly 300 years, and the delicate odor of the wood, which made them popular with the early colonists, is their chief recommendation now. It has always been held that this odor will keep moths and other insects at a distance, and thus protect furs and clothing stored in the chests. The modern chest and wardrobe manufacturer is obliged to make use of cedar wood containing many knots, and with much white sapwood along with the red heart; but this is not held to lessen in any way the value of the commodities produced, and many persons consider the chest made of the variegated wood to be more artistic than if of one solid color.

BOAT BUILDING.

Comparatively large quantities of red cedar were employed by ship carpenters and boat builders nearly 200 years ago. Even earlier than that a small amount was hewed into canoes by white men, and the Indians sometimes made dugouts of it. The drain upon the forests began when shipbuilders discovered that red cedar and oak, particularly live oak, formed a combination valuable in naval construction. The cedar was generally considered too weak for the frames and keels of large vessels, although entire ships were sometimes made of a very similar cedar in the Bermuda Islands. The builders of vessels along the Atlantic coast made the keels and lower parts of live oak or white oak and the superstructure of cedar. This made an appropriate distribution of weight, the heaviest in the bottom, where it served as ballast as well as to give strength, and the lightest in the parts above water. Exact statistics of the amount taken for shipbuilding are not available, but it was comparatively large and called for the very finest trees available. The largest demand is assumed to have been for seagoing vessels, yet much was required for river craft on the Hudson, Delaware, and farther south.

Whale fishermen made a comparatively large demand for the very best grade of red cedar for whaleboats. In the days when a large part of the whale fishing of the world was centered in New England and when large fleets sailed yearly from New Bedford and other harbors for every whaling ground in the world the whaleboat was an absolute necessity. That was before the days of the harpoon gun,

[1] M. Theo. Hariot in Hakluyt's Voyages, vol. 3.

when the hunter learned to kill the game with machinery and at long range. It was then a fight to the finish in immediate contact. In the whaler's phrase, it was "wood to black"—that is, the wooden boat was thrust against the whale's black body—and the harpoons and spades were plied by skilled and fearless men. Having made fast to the monster, the next feat was to cut the tendons of the flukes with a broad-pointed harpoon, called a spade, to weaken the whale and prevent his crushing the boat or making a dash to sea against the wind and dragging the boat with him to destruction. In the fierce contact of such a fight everything depended upon the boat's standing the shock of blows. Red cedar is not the strongest wood—it is really one of the weakest and most brittle—but that was what fitted it for that special use. The frame of the boat was made of oak, but the sides and bottom were of cedar, which would break under a sharp blow sooner than split. A stroke from the whale's fluke would knock a hole in the side, but the wood did not splinter. The same blow would split and splinter from end to end a boat of most other woods, and it would fill at once and sink. Not so with the cedar boat. The hole could be plugged instantly with a mat or blanket kept for that purpose, or in an emergency a man's coat would plug it and keep the men afloat and in the fight.

MANUFACTURE AND PRODUCTS.

No time can be stated, even approximately, when the primitive uses of cedar ceased and manufacturing began. In some lines the wood is now used in about the same way that it was used 200 years ago. As previously said, it has never been extensively sawed for lumber, and in that respect it differs from most of the abundant species of this country. Fence posts of red cedar were a commercial commodity in Pennsylvania and New Jersey 160 years ago and in the Carolinas 200 years ago, and at the same time sold at a price not much below their market value at present, $250 a thousand, reckoning money at its present value. From that time till the present red cedar posts have been manufactured by hand and sold to farmers.

Sawmills were cutting and exporting red cedar boards from New Jersey in 1750. Present furniture manufacturers are simply continuing a business almost as old as the settlement of the Atlantic coast by white men. There has been some improvement in methods of manufacture, and scarcity has taught economy in using the high-grade wood; but in durability and appearance modern cedar furniture has little advantage over that a century or two centuries old. The wood is put to many purposes, as bookshelves, cabinets, brackets, table tops, but rarely as bedsteads now. Its enduring properties make it popular for out-of-doors furniture and fixtures, such as rustic seats, bridges, benches, trellises, railings, and summer houses.

Planing mills make interior finish of it, but not in large quantities, ecause of the scarcity of suitable lumber. It is seen in porch and iterior columns, panels, molding, railing, frames, balusters, and air work. It is listed as coffin and casket material, but the quantity ms used can not be large. It was so used in the South 200 years go. Its early use as cooperage continues in considerable volume. 'he list of such articles includes tanks, buckets, keelers, firkins, pigins, tubs, and many kinds of small receptacles for the kitchen and antry. An important center of that industry was for a long time in 'ennessee.

It is of historical interest that red cedar was one of the earliest oods mentioned for cooper's work in the Ohio Valley. In 1762 tubs ere made of it on the Muskingum River in Ohio by C. F. Post and ohn Heckwelder, who had established a missionary station among e Indians in that region.

Very little of this wood is now employed in shipbuilding, but in essels of smaller size it is common. It is used as trim for yachts nd in canoes. Novelty makers find it suited to their needs as recepcles for salt, boxes for buttons, collars, gloves, and toilet and mily articles. Red cedar faucets are a staple article in trade, as r the past century and a half. Occasionally water pipes are made f the wood. The maker of cigar boxes draws a considerable part of is supplies from it. It is generally cut in thin veneer and is laid a backing of tupelo or some other light, substantial wood. For is purpose red cedar is a strong competitor with the Cuban or panish cedar. Telegraph and telephone poles constitute a comratively recent use for this wood, and a considerable one. Several ecies, commercially known as cedar, are grouped as one in available atistics, and the number drawn from red cedar can not be deterined. But they are cut in all parts of this tree's range, and the outh in particular is heavily drawn upon. The poles decay slowly d are good for long service. In a few localities complaint is eard that woodpeckers single out red cedar telephone poles for tack, and excavate nests in them, sometimes so weakening them that ey snap off in storms. It is thought that the softness of the wood, d possibly its odor, invite the birds. Attempts to drive them away plugging their nests with stones have usually made matters worse, r the birds industriously apply their bills to the excavation of a w nest beside the stone packing in the old, and the pole is further eakened.

LEAD PENCILS.

Red cedar is the best lead-pencil wood. Pencil manufacturers ocured it in the United States 100 years ago, though at that time e wood was so abundant and the demand for pencils so small that e cut for that purpose was almost negligible. The makers of pen-

cils in Germany took measures long ago to provide this wood without the expense, trouble, and uncertainty of importing it, and planted red cedar. The plantings have thrived, but they fall short of furnishing European manufacturers what they need of the wood, and the United States is still called upon to furnish the principal supply.

Though red cedar was one of the earliest trees to claim the attention of foresters in this country, it has not been much planted for commercial purposes, and the natural growth is depended upon to meet the demands. Pencil manufacturers can afford to pay higher prices for good cedar than most other manufacturers, and in consequence the choice wood goes to them. They often buy it by weight, and the price ranges from 30 to 40 cents a cubic foot, or about 1 cent a pound. The annual demand in this country reaches 110,000 tons, which makes 320,000,000 pencils. The cost of the cedar per pencil is about three-fourths of a cent. This is because as much as three-fourths of the pencil wood purchased never actually enters a pencil, but goes to the waste heap, or is worked into some by-product, as carpet paper or packing shavings. It is estimated that 70 per cent of the bulk and 90 per cent of the weight of pencil cedar purchased goes to the waste pile. It is thus apparent that the pencil maker is one of the most exacting manufacturers who work in wood. The wood must be soft, and this causes rejection of cedar growing outside of a certain limited region in the South. The grain must be straight and free from knots, and this excludes all but clear trunks, though cedar boles are not usually clear many feet of their length. Red rot must be rejected, and this often causes loss of a large part of a log. Black specks, due to old dormant buds, lessen the value of the wood, but do not prevent it from going into cheap pencils. The sapwood and some of the heartwood which is not quite up to the standard for pencils frequently goes to the penholder maker; but the demand is small, and much of that class of wood is destroyed because unsalable. In the past the sapwood was frequently got rid of by allowing it to rot. To hasten the process, the logs were buried under water until the sapwood softened, when it was more easily removed. The process improves the heartwood by softening it and making it brittle, qualities appreciated by pencil makers. At present both sapwood and heartwood are used in pencil making.

The search for pencil wood has been widespread and thorough. Formerly new supplies could always be found by going a little farther back, but the time has now come when virgin stands need not be expected. Cedar cruisers have explored all important districts and first-class timber has nearly all been cut. Old cuttings have been gone over; logs and trees passed by in early years are now taken. Even old stumps are cut, and some first-class wood is thus obtained. The barns and cabins built of cedar logs and planks many years ag

ire not escaping the searchers, and the pencil makers buy this wood n large quantities. Fence rails and pickets go the same way. In some cases the pencil men secure old cedar rail fences by constructing n their places modern woven-wire structures.

A wide and vigorous search for substitutes for red cedar pencil wood ias been going on for years. Use of a number of woods has been nade, but a substitute in all ways satisfactory has not been announced.

BY-PRODUCTS.

The by-products belonging to red cedar are of minor importance, out are of some value. Shavings are employed to drive moths from clothes presses, and a paper made from the waste in lead-pencil factories is placed under carpets in the belief that it protects against nsect attacks. It at least serves the same purpose as any other paper n that position. In some parts of the country the pioneers made tea f red cedar chips, which passed as a substitute for the Chinese commodity. Manufacturers of perfumery use a product distilled from ie leaves and wood of the tree. An ointment made by boiling the esh leaves, and also from powdered dry leaves, is reputed a remedy or blistered feet. Red cedar sawdust is sometimes employed by eat packers in smoking meat. Black walnut and mahogany sawust are used for the same purpose.

WESTERN JUNIPER.

(*Juniperus occidentalis.*)

PHYSICAL PROPERTIES.

Weight of dry wood.—35.9 pounds per cubic foot. (Sargent.)

Specific gravity.—0.57. (Sargent.)

Ash.—0.12 per cent of dry weight of wood. (Sargent.)

Fuel value.—92 per cent that of white oak.

Breaking strength (modulus of rupture).—6,600 pounds per square h, or 50 per cent that of white oak. (Sargent.)

Factor of stiffness (modulus of elasticity).—1,060,000 pounds per iare inch, or 50 per cent that of white oak. (Sargent.)

Character and qualities.—One of the heaviest of the cedars, soft, ain fine and even, compact, brittle, splits easily; annual rings ually narrow, summerwood thin, not conspicuous; medullary rays merous, very obscure; color, brown tinged with red, the sapwood arly white; slight aromatic odor; works easily; durable.

Growth.—Height 25 to 45 feet, diameter 2 to 4 feet.

SUPPLY AND USES.

Range, Idaho, eastern Oregon, through Cascades and Sierras to pthern California. The supply of western juniper is not large, nor e its uses many, but certain habits of growth and properties of the

wood give it an importance in many parts of its range. It is a good fuel, and being a high-mountain tree, provides it in many places where other fuel is exceedingly scarce. The tree grows in poor, rocky, wind-swept soil, though it responds to more favorable surroundings by more rapid development and better form of trunk and crown. It is seldom or never cut for lumber, in the ordinary meaning of the term, because the trunks are too short for saw logs. Clear boles more than 6 or 8 feet long are unusual. The wood lasts a long time, and makes durable fences. It gives good service as railway ties, and roads building through regions where it abounds cut all within reach. It is of such slow growth that few owners of land think much of second-crop prospects. A trunk diameter of 20 inches would probably not be reached in a century, and it is supposed that the largest specimens are from 500 to 800 years old.[1] The tree's redeeming feature is that it grows where scarcely any other tree can maintain an existence.

The fine grain, handsome color, even texture, and other characteristics of western juniper indicate that it would make good lead-pencil stock. Though the trunks are too short for saw logs, they might be advantageously manufactured into bolts for pencils.

Other Species of Juniper.

A number of other junipers are found in the region between the Plains States and the Pacific coast. None of them rate very high in commercial importance, yet they are of considerable value in certain localities.

The Rocky Mountain juniper (*Juniperus scopulorum*) is one of the most important of the group. It is found over much of the Rocky Mountain and Plateau region and ranges eastward into Nebraska and South Dakota. Its uses are nearly identical with those of the western juniper.

One-seed juniper (*Juniperus monosperma*) is more restricted, and ranges through parts of Colorado, New Mexico, Utah, and Texas, and within its range is extensively used for ranch timber and fuel. So far as known it is not sawed, and is used only locally, but wood for posts and fuel has been hauled by settlers from the foothills to the valleys and plains. This wood and piñon were often the only ones available.

California juniper (*Juniperus californica*) is a small tree, 20 to 3[?] feet high, in southern California. The wood resembles that of western juniper, and has similar uses. It is likewise a poor-land tree, and thrives on low desert slopes and plains, where it supplies many of the needs of stockmen, miners, and campers. In some localities it is the chief dependence for fuel and fences.

[1] John Muir, in "The Mountains of California," says the tree attains an extreme age of 2,000 years.

Utah juniper (*Juniperus utahensis*) ranges over the desert regions of Utah, Colorado, Nevada, California, and Arizona. It is too small for lumber, its height seldom exceeding 30 feet, but for fuel and fencing and about ranches and stock corrals it is indispensable in some regions and of considerable use in many others. Trees 10 inches in diameter are sometimes 250 years old, showing it to be of exceedingly slow growth.

Alligator juniper (*Juniperus pachyphlœa*) is the prevailing and largest juniper of the mountains of western Texas, and extends its range into Arizona. It has many names, among them juniper, oak-barked cedar, mountain cedar, thick-barked juniper, and checker-barked juniper. It attains a height of 25 to 45 feet, and a trunk diameter sometimes of nearly 4 feet. Its stem is usually too short for lumber, but a good-sized tree will often turn out many fence posts. It is a desert tree and is found in regions where other timber is scarce. Because of this fact it is of importance for fuel and rough ranch timbers.

INCENSE CEDAR.

(*Libocedrus decurrens.*)

PHYSICAL PROPERTIES.

Weight of dry wood.—25 pounds per cubic foot. (Sargent.)

Specific gravity.—0.40. (Sargent.)

Ash.—0.08 per cent of dry weight of wood. (Sargent.) This is a very low per cent of ash and is equaled by few American woods. Douglas fir, however, has the same rating.

Fuel value.—54 per cent of white oak. (Sargent.)

Breaking strength (modulus of rupture).—9,500 pounds per square inch or 72 per cent that of white oak. (Sargent.)

Factor of stiffness (modulus of elasticity).—1,180,000 pounds per square inch or 56 per cent that of white oak. (Sargent.)

Character and qualities.—Very light, soft, not strong, brittle, grain fine, straight and even, annular rings narrow; compact, summerwood thin, dark colored, conspicuous; medullary rays numerous, obscure; the sapwood nearly white; easily worked on account of its softness and even texture; very durable in contact with the soil.

Growth.—Height 75 to 125 feet, diameter 3 to 6 feet.

SUPPLY.

Practically all the incense cedar that finds its way into local or general markets is cut in the State of California. The tree's range extends into Oregon and overlaps a little on Nevada, but not much timber is cut in those States. In some parts of California it is abundant, or once was, and in other parts there is none. Much of the

best comes from the western slopes of the Sierra Nevada Mountains, and very good timber is found at elevations of 5,000 or 6,000 feet. The total available quantity is not known further than that it falls much short of sugar pine, western yellow pine, redwood, and perhaps other California species. It does not grow rapidly. A tree 2 feet in diameter may be 200 years old, and a century is not an unusual period for the growth of each successive foot in diameter. The shape of the trunk does not make it ideal for saw logs, because the base is generally much larger than the bole 10 feet above.

USES.

A large part of the incense cedar cut in California has been made into fence posts. The wood is durable and compares favorably with redwood. The post makers usually split the timber after removing the thick sapwood, which is not acceptable as post material. In small trees and those of medium size the waste caused by rejecting the sapwood is very large, sometimes approximating half the tree. Post makers often prefer fire-killed timber or standing trees that have died from any cause and have subsequently passed through fire. The sapwood of such timber is usually consumed by the flames, leaving the heartwood little injured if it was previously sound. The fact that a dead cedar passes through a fire without being wholly consumed is strong evidence, in the eyes of an experienced post maker, that the charred trunk is sound. If it were not sound, it would have burned and fallen.

Approximately one-half of the incense-cedar timber, as it stands in the woods, is defective. A fungus (*Dædalia vorax*) attacks it with persistent energy and excavates pits throughout the entire length of the trunk. These galleries resemble the work of ants, and not infrequently ants take possession of them, and it is not improbable that they occasionally enlarge the galleries made by the fungus. This disease is called " pin rot," and though it weakens and disfigures the wood it seldom advances so far as totally to destroy its usefulness. When a tree is cut down the fungus ceases its work.

Though posts for the farmers' fences probably constitute as heavy a drain upon the wood as all other demands combined, it has several other important places in local industries. Lath for plastering, and also lath on which to nail shingles, are made of it. Much has been sawed into shingles, which last well. It is a serviceable and fairly handsome furniture wood, and some of it goes for that purpose. Interior finish is in the same class with furniture, and the wood supplies a number of demands in that line. It is listed as a cigar-box material and in color and texture of wood it very well fulfills conditions in that trade. Incense cedar has recently been tried as a pencil wood

and apparently has given good results, as large orders for the wood have been placed by the company which made the experiments. In this use it replaces red cedar. It has been put to extensive use in building irrigation, mining, and other flumes. The bark is employed on mountain roads as a covering to prevent excessive wear, to lessen the dust nuisance in the dry season, and to hinder washing in time of hard rains. The wheels of vehicles grind it to shreds, which pack into an elastic cushion that resists wear for a considerable time.

Incense-cedar boards, 16 feet long or less, are occasionally shipped from the Pacific coast to New York, Boston, London, Paris, and Berlin.

Port Orford Cedar.

(*Chamæcyparis lawsoniana.*)

PHYSICAL PROPERTIES.

Weight of dry wood.—28.8 pounds per cubic foot. (Sargent.)

Specific gravity.—0.46. (Sargent.)

Ash.—0.1 per cent of dry weight of wood. (Sargent.)

Fuel value.—62 per cent that of white oak. (Sargent.)

Breaking strength (modulus of rupture).—12,400 pounds per square ch or 95 per cent that of white oak. (Sargent.)

Factor of stiffness (modulus of elasticity).—1,750,000 pounds per uare inch or 84 per cent that of white oak. (Sargent.)

Character and qualities.—Light, moderately strong, grain fine and en, compact; annual rings usually narrow, summerwood not conicuous; medullary rays numerous, very obscure; abounding in odorerous resin, satiny, susceptible of a beautiful polish; color light llow or almost white, occasionally reddish, the thin sapwood hardly istinguishable; very easily worked and durable.

Growth.—Height 135 to 175 feet, diameter 3 to 7 feet. Formerly ees much larger were common.

SUPPLY.

This tree is found in southwestern Oregon and northwestern Calirnia, scattered over a region of more than 10,000 square miles; but e bulk of commercial timber is grouped in an area of 300 or 400 iare miles, chiefly in Oregon.

Compared with many other American timbers, the supply of Port ford cedar was never large, because its range is local. Within that nge, however, a heavy growth once stood, though it has been greatly pleted. Estimates of that stand, based on what remains in certain alities, place it at more than 4,000,000,000 feet. Exceptional acres ve yielded 100,000 feet, and over much of the region where it was

at its best, exceeded 20,000 feet per acre. The timber is not yet exhausted, but it is much scarcer than formerly. The whole history of this timber, from its first announced discovery by white men to the present time, is embraced in the memory of living men. It was discovered in 1855 in the region about Coos Bay, Oreg. A few years later a great forest fire swept the region, and the Port Orford cedar suffered severely, much of the finest timber being killed. The naked trunks in many instances stood 40 years, and were sound at the end of that time. Those that fell likewise remained sound a long term of years.

BOAT BUILDING.

One of the earliest uses to which the people of the Pacific coast put this fine timber was boat building. An important, though not large, industry existed at Coos Bay. Ships large enough to successfully engage in the coast trade were built there, chiefly of Port Orford cedar. That they met every reasonable requirement is evident from the fact that after serving 40 years some of them were declared to be still staunch and strong and good for many years more. The large trunks turned out a high per cent of clear planks, free from knots and other defects, and admirably suited to ship construction. The resin or oil in the wood has been credited with preservative properties which hinder decay. This timber has remained a favorite material for boat building, and small lots of it find their way to many factories in all parts of the country and are made use of in the construction of yachts and other small vessels.

MANUFACTURE AND PRODUCTS.

Dead trees are sawed and split into bolts and are bought by match factories. Small sections of solid wood in defective trunks are cut out for matches. Mills in the range of this cedar saw lumber for general construction purposes, and a specialty is made of grades suitable for interior finish. The wood dresses well and presents a handsome appearance. It is sufficiently hard to make it suitable for floors, and that is one of its chief uses. Some of it goes into furniture in local factories, serving for drawers, shelves, and compartments, while cabinetmakers work panels from clear stock. Porch columns, newel posts, balustrades, spindles, and railing are made of it.

The odor of Port Orford cedar is offensive to most insects that infest clothes chests and wardrobes, and it is claimed that furs and woolens are never attacked while stored in boxes or drawers of this wood. Its use in the construction of such commodities is found in the East as well as in the West. It is made into clothes chests, shirtwaist boxes, chests, wardrobes, hat cabinets, nests of boxes, and similar articles. The interiors are left in the natural state of the wood it

order that the odor may freely distill, but the exterior of the articles is finished to match many woods, such as mahogany, golden oak, English oak, weathered Flemish, fumed, forest green, and others.

The manufacturers of broom handles have found this an excellent wood for their line, and not only are local markets supplied, but regular shipments of broom handles are reported for China, Japan, South America, and elsewhere.

Yellow Cedar.

(*Chamæcyparis nootkatensis.*)

PHYSICAL PROPERTIES.

Weight of dry wood.—29.8 pounds per cubic foot. (Sargent.)

Specific gravity.—0.48. (Sargent.)

Ash.—0.34 per cent of dry weight of wood. (Sargent.)

Fuel value.—64 per cent that of white oak. (Sargent.)

Breaking strength (modulus of rupture).—11,000 pounds per square inch, or 84 per cent that of white oak. (Sargent.)

Factor of stiffness (modulus of elasticity).—1,460,000 pounds per square inch, or 70 per cent that of white oak. (Sargent.)

Character and qualities.—Rather light, hard, fairly strong, brittle, grain fine, even, and straight, compact, annual rings narrow and indistinct; summerwood thin, not conspicuous; medullary rays thin, numerous, hardly distinguishable; easily worked, satiny, susceptible of a beautiful polish, possessing an agreeable, resinous odor; color bright, light clear yellow, and thin sapwood scarcely distinguishable; durable in contact with the soil.

Growth.—Height 90 to 120 feet, diameter 3 to 6 feet.

SUPPLY AND USES.

Yellow cedar has a geographic range of nearly 1,000 miles along the Pacific coast and the adjacent islands from Oregon to southeastern Alaska. The strip constituting its range is nowhere broad and in most places is very narrow. Estimates of the available supply are too general to be of much value, but it is well understood that the amount is very large. It is said to be the most valuable wood in Alaska, and as a cabinet wood its beauty has been declared by some to be equal to that of any other tree of North America. Its rare color and the fine polish which it takes constitute two of its chief values; but it has others, one of which is its power to resist decay in the most unfavorable situations. Logs lying upon the damp ground have been known to remain sound for half a century.

Statistics do not exist to show the quantity of yellow cedar put on the market yearly. Statistically the wood is not distinguished from

western red cedar, and even the latter is not always distinguished from other so-called cedars. Yellow cedar deserves to stand on its own merits, and doubtless will when its fine qualities become better known. It has been employed in ship and boat building for many years with most satisfactory results. In this use it competes with Port Orford cedar.

The Indians of southern Alaska and British Columbia prefer this wood for canoe paddles, 30 to 40 of which are necessary for their largest canoes.

Yellow cedar has recently come into favor for interior finish, cabinets, shelving, molding, and floors. Pattern makers draw supplies from it, and it competes with white pine. It is excellent for pyrography, the even grain making it one of the best for that purpose and a close competitor with basswood. Novelty makers, who use many woods from many regions, find this one of the best for a number of purposes, and it is being tried at present for shuttles. It is made into furniture and ranks among the choice soft woods for that purpose. Its use for furniture will probably become extensive on account of its hardiness, evenness of texture and color, and its distinctive pleasing appearance. It is taking the place of Spanish and red cedar for cigar boxes, though the use is not yet extensive. In the search for a substitute to take the place of red cedar in lead-pencil making yellow cedar has been favorably mentioned, but it is not considered equal to red cedar, being harder and heavier.

The wood has been exported in considerable quantities to China, where it has been used as a substitute for satinwood.

WESTERN RED CEDAR.

(Thuja plicata.)

PHYSICAL PROPERTIES.

Weight of dry wood.—23.7 pounds per cubic foot. (Sargent.)

Specific gravity.—0.38. (Sargent.)

Ash.—0.17 per cent dry weight of wood. (Sargent.)

Fuel value.—51 per cent that of white oak. (Sargent.)

Breaking strength (modulus of rupture).—10,500 pounds per square inch, or 81 per cent that of white oak. (Sargent.)

Factor of stiffness (modulus of elasticity).—1,460,000 pounds per square inch, or 70 per cent that of white oak. (Sargent.)

Character and qualities.—Light, soft, not strong, brittle; grain coarse, even, and straight, compact; annual rings rather wide and even; summerwood about half the width of the ring, dark colored, hard, distinct, medullary rays numerous, obscure; color dull brown,

tinged with red, the thin sapwood nearly white; easily worked; durable in positions exposed to decay.

Growth.—Height 100 to 150 feet, exceptional trees 200; diameter 3 to 8, extreme 16 feet.

SUPPLY.

The western red cedar grows in sufficient abundance over an area of 300,000 square miles to make it attractive to lumbermen. This region embraces portions of northern California, Oregon, Washington, Idaho, British Columbia, and Alaska. The principal cut has been reported from Washington, and that State may be considered as the center of supply. The best timber comes from regions of abundant rainfall and mild humid climate. Near the species' southern limit in California it clings to the fog belts. Its extensive range and the fact that it does not usually occur in pure stands of large extent make estimates of the total available supply difficult. It is certain that cutting in late years has been more rapid than growth, but it is not known how long, at the present rate of cutting, the timber will last. It is not believed, however, that the end will arrive in the near future, although the drain upon the forests is very heavy, and has been for years.

Nature made ample provision for the spread of the species. The light seeds are fairly abundant, and having two wings, they are great travelers and search out favorable situations for germination and growth. Forest fires are the tree's worst enemy. The bark is thin, and a brisk blaze, though of only short duration, is usually sufficient to kill mature timber, while small growth seldom escapes. After the fire has passed, if it has burned the humus in the soil sufficiently to lessen its capacity to retain moisture, the seeds of this tree do not readily germinate. For that reason the tree seldom follows fires, as lodgepole pine does in the West and paper birch in the East. Under normal conditions western red cedar is not exacting in its requirements. It grows in dense shade, and lumbermen cut much excellent timber in deep forests; but shade is not essential, and good lumber comes from tracts where other growth is thin and light is abundant.

It is not so essential in the case of western red cedar as with some other timbers that the trees be cut when they reach merchantable size. They will stand a long time after that before deteriorating. Trunks in good condition at the age of 600 or 800 years have been reported, but the majority of fully matured trees are not so old. Claims of ages 1,500 years or more have been made, but have not been fully substantiated. It is well known, however, that trunks that fell in damp woods centuries ago have lain beneath moss and soil

until the present day in a sound condition. Timber of this kind figures to a limited extent in the lumber supply. Logs dug from swamps, or exposed to view when the moss and humus have been burned off, are sometimes manufactured into shingles or lumber. Cases are vouched for in which the ages of trees growing upon buried logs show that the prostrate trunks fell five or six centuries ago, and even more, and though they have lain so great a period they are found fit for merchantable lumber.

EARLY USES.

The Indians made much use of western red cedar before white men became acquainted with the region in which it grew. From it they obtained food, clothing, shelter, means of transportation, and apparatus for fishing and the chase. From the tree trunks the savages made canoes of all sizes, from the small trough that carried two men to the enormous dugouts that transported 50 or more upon long expeditions in war and peace. Before the Indians obtained metal tools from white traders they hollowed their canoes with fire and with their primitive stone and bone implements. Some of their dugouts are of enormous size, hewed from single trunks, and with lines so perfect that civilized men can scarcely suggest improvement.[1] The making of a canoe of moderate size, by the crude means at the Indians' command in the early days, required several months of hard labor with flint adzes that chipped away pieces of wood not much larger than grains of sawdust.

When Lewis and Clark crossed the Rocky Mountains and reached the tributary waters of the Columbia River in the summer of 1805, they saw for the first time the canoes of the Indians made of this wood. Some months later when the explorers found it necessary to abandon their pack animals and trust to the rivers to carry them to the Pacific, they made their canoes of cedar, and the small fleet successfully descended the Columbia and carried the explorers to the ocean. So common was the use of this wood for dugouts that with many persons its only name was canoe cedar.

The Indians nearly always made their totem poles of this wood, because it is soft and they could work it easily with their rude tools.

[1] It is claimed that canoes made by the Alaska and British Columbia Indians were early taken by fur traders to Boston and New York, where they became the patterns by which the celebrated clipper ships were built. One of the canoes, now in the National Museum, in Washington, is 59 feet long, 8 feet beam, 7 feet 3 inches deep at bow, 5 feet 3 inches at stern, and 3 feet 7 inches in the middle. It was made on Vancouver Island with Indian tools, and is capable of carrying 100 persons with their camp outfits. The canoe is 19 feet longer than the *Sparrow Hawk*, which brought settlers from England to America in 1626. It is said that even larger canoes have been hewed from single trunks of western red cedar. A flare is given the large canoes after the hewing is done, and the width of the beam is increased 8 to 12 inches. The canoe is filled with water which is brought to a boil by dropping in hot stones. When the wood is softened by the heat, the flare is given by inserting braces.

It was valued likewise because it resisted decay a long time, and when the grotesquely carved pole had once been set up in the village or at the cemetery, it could be reasonably expected to stand at least during the lives of those who made it and set it up. Some of these gigantic trunks hewed in forms of men and beasts, often with considerable skill, are the largest pieces of single wood carving in the world, greatly exceeding in size the largest columns and doors of European cathedrals.

The Indians of the region where western red cedar abounded generally chose it for such rude carpentry as they were capable of doing. Their choice was due to the softness of the wood, which meant a great deal to men who hewed and shaped their beams and doors with no better tools than fire, flint, bone, and shell. They made fully as much use of the bark as of the wood. With it they roofed, ceiled, floored, and papered their huts. They wove long strips of bark—sometimes 30 feet in length—into mats, which they used for beds, tables, blankets, and on ceremonial occasions. They made clothing of the same material. They twisted the bark into ropes for dog harness, ladders, fishlines, and snares for wild animals and nets for catching fish. The list of uses for the bark did not end there, for they were able to make food of it. They beat the bark to a pulp, baked it in cakes, and after completely saturating it with salmon oil they pronounced it a palatable and nutritious article of diet. It is believed, however, that the food value of the cakes was derived more from the fish oil than from the bark.

The first white settlers in the region adopted many uses of this wood from the Indian, but the chief was for canoes. What the yellow poplar was as a canoe wood to the early settlers in the East the western red cedar was to the frontiersman and trader in the Pacific region from Alaska southward.

Its value for shingles was early discovered, and as soon as the cabin took the place of the woods camp the shingle roof put in an appearance. The doors and window frames, as well as joists and rafters, were frequently of the same material. The wood's softness had tempted the Indians to use it, and the same property appealed to the white men who succeeded the Indian as the possessor of the country. It was one of the first woods cut for fences, and for many years it was commonly so used wherever it was within reach. It was employed for rails and for posts, and its long resistance to decay is shown by the fact that some of the fences built nearly half a century ago were doing service until very recently.

In the days when cooperage was handwork on the Pacific coast, and tubs and pails were made in each neighborhood, the cedar was one of the choice woods, because convenient, easy to work, handsome in appearance, and serviceable for many years.

MANUFACTURE AND PRODUCTS.

Western red cedar is the greatest shingle wood in the United States at this time, and has held that place for some years, with no likelihood of giving it up in the near future. The average output from this wood alone, and chiefly in the State of Washington, is not far short of 20,000,000 shingles for every day in the year. In 1908 it furnished 63 per cent of the total shingle cut of the United States. Redwood shingles, made only in California, appear with it in the eastern markets, but they form only one-eighth of the cedar output.

This cedar is extensively cut for poles in Washington and Idaho, and large-size poles of this wood are now shipped to nearly all parts of the United States under the name of Idaho cedar. The very long poles seen in city streets are generally of this wood, because other woods do not afford the necessary length. Poles cut from this species taper regularly, and present an attractive appearance when set in line. Their ability to resist decay likewise adds to their value along streets and suburban roads where frequent resetting through cement and asphalt is expensive. Country telephone poles are from 20 to 30 feet long, railway telegraph poles from 25 to 40 feet, and those in cities from 40 to 75 feet.

The wood is used for car siding and roofing, positions where great strength is not required.

More is now used in boat building than in the days of the Indian canoes on western waters, but it serves in a different way. It is now a highly finished product, and is worked by skiff makers and yacht carpenters. It provides handsome trim, lining, railing, and roofs.

It finds more and more demand as interior finish for houses, stores, and offices. Pattern makers use it, and it is seen in window and door frames, and in sash and doors, in molding, chair boards, stairways, panels, and porch work. It fulfills the requirements of outside finish as well as inside, and is being cut into bevel-edge siding in large quantities in many western mills. Cabinetmakers use it for many purposes—the backs and sides of drawers, shelves, boxes, and partitions. It is worked into frames and sash for hothouses, as well as sash for ordinary windows.

Its use in cooperage has come down to the present time, and where it was formerly shaped by hand it is now manufactured by machinery into buckets, pails, tubs, tanks, and the whole line of similar articles.

CYPRESSES.

Although seven species commonly known as cypresses grow in the United States, only one, bald cypress (*Taxodium distichum*), is of great commercial importance. *Taxodium imbricarium*, a closely related species, occurs in the same range as bald cypress and is cut and

used with it. The others, a distinct group of trees, are Monterey cypress (*Cupressus macrocarpa*), Gowen cypress (*Cupressus goveniana*), Macnab cypress (*Cupressus macnabiana*), Arizona cypress (*Cupressus arizonica*), and smooth-bark cypress (*Cupressus glabra*). All of these, because of their limited supply, are put to but small and local use.

Bald Cypress.

(*Taxodium distichum.*)

PHYSICAL PROPERTIES.

Dry weight of wood.—27.6 pounds per cubic foot. (Sargent.)

Specific gravity.—0.45. (Sargent.)

Ash.—0.42 per cent of dry weight of wood. (Sargent.)

Fuel value.—61 per cent that of white oak. (Sargent.)

Breaking strength (modulus of rupture).—7,900 pounds per square inch on pieces 4 by 4 by 60 inches, with 12 per cent of moisture. (Forest Service Circular 15.)

Factor of stiffness (modulus of elasticity).—1,290,000 pounds per square inch on pieces 4 by 4 by 60 inches, with 12 per cent of moisture. (Forest Service Circular 15.)

Character and qualities.—Light, soft, not strong, grain rather fine, straight; annual rings narrow; summerwood broad, slightly resinous, conspicuous; medullary rays numerous, very obscure; color light to dark brown, the sapwood nearly white; easily worked; very durable in contact with soil.

Growth.—Height 75 to 140 feet, diameter 3 to 6 feet, in exceptional cases 10 feet.

SUPPLY.

Bald cypress is found in commercial quantities in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, Texas, and Virginia.

In 1898 the amount of standing cypress in the United States was estimated to be 27,000,000,000 feet. The cut since that time has exceeded 5,000,000,000 feet, and the new growth has counterbalanced only a small part of this. A hundred years ago Michaux said: "It is highly probable that in less than two centuries the cypress will disappear from the Southern States." He was led to that prediction by observing the slow growth and the scanty reproduction of the species. At that time the cut for lumber was comparatively small, but cypress swamps were frequently cleared for rice fields. Cypress is not now being planted, and perhaps never will be, for the purpose of growing commercial timber. Natural reproduction must be depended upon, and this does not keep pace with the cutting. Few

cypress trees are large enough for lumber at an age of less than two centuries, and many do not reach sufficient size until much older. The present demand requires 750,000,000 feet yearly, with a marked tendency to increase during the past 10 years. Depletion of supply in the immediate future is not likely, but every year sees a smaller quantity to draw upon. Cypress is an expensive timber to cut and log. It grows in swamps covered with water much of the time. It is customary to dig canals in which to tow the logs to the mills, or to construct railroads through the swamps, driving piles on which to rest the ties. The butt cuts of large cypress trees will not float when green, and to overcome that it is customary to girdle the standing trees several months before felling them. This permits them to dry sufficiently to float. Cypress mills operate on a large scale. In 1908 the average cut per mill was 840,000 feet. That was exceeded per mill by those cutting redwood, Douglas fir, and yellow pine, and none other. Mills cutting maple averaged 128,000 feet, spruce 440,000, hemlock, 400,000, white pine 480,000, oak 170,000, and yellow poplar 100,000 feet per year. In 1908 more than half of the cypress lumber was sawed in Louisiana. Florida came next, with about 8 per cent, while small amounts were sawed in 16 other States, including Delaware, Illinois, and Indiana, and most States south of them. The logs sawed into lumber in Indiana, Illinois, and Delaware were probably brought from States farther south.

EARLY USES.

In the parts of the South settled by the Spanish, houses were generally built of cypress. A century ago there were few houses in New Orleans which were not constructed wholly or in part of this wood, and even outside of the Spanish settlements it was extensively used. Cypress shingles were regarded as so much superior to any others that their use became extensive at a very early period. They were easily made by hand, and were very cheap when suitable timber was abundant. They were split with mallet and frow and sometimes shaved with drawknives. The splitting was done parallel with the rings of annual growth, while with white pine and most other shingle timbers the splitting was done perpendicularly to the annual rings. As with many other woods, it is only the heartwood that shows great durability. The sapwood lasts but a few years when subjected to conditions favoring decay. On the other hand, instances have been cited, on what is apparently good authority, showing remarkable periods of use for heart cypress shingles. A roof at Greenwich, Conn., was laid in 1640, and was said to be serving well 250 years afterwards; another in Brooklyn, N. Y., was said to have lasted 228 years; and another at Clifton, Staten Island, had 200 years to its credit when last reported, and was still in use. Many instances

of use exceeding a century are cited to show the wood's lasting qualities. This is not only true when used as roofs, but for other purposes. New Orleans cypress water mains remained sound nearly a century, and a cypress headboard at a grave in South Carolina was so well preserved after 140 years that the letters on it were easily read. Marble and sandstone gravestones often decay and crumble in less time. A still longer period has been claimed for cypress coffins at Charleston, S. C. It is said they were found in fair condition at the time of the earthquake, though they had been in the ground since 1678.

Along the lower Mississippi River many plantations were once fenced with cypress. Some of it was made into rails, while in other cases it was used as posts with boards nailed on. Undoubtedly all of these cases of great durability represent only heartwood, and that from mature swamp-grown trees.

South of the region of the yellow poplar, the best canoe wood in early times was cypress. Dugouts were almost the only kind of canoe made in the region. John Lawson, writing about 1714 upon the resources of North Carolina, gives valuable information upon the cypress canoes' part in the coast and river commerce at that time.[1] Canoes upon the rivers had a capacity of 30 barrels, and were freighted with flour, lumber, and other commodities. Some were sawed down the middle lengthwise and a piece of wood inserted to make them wider, and they then carried 80 to 100 barrels. The cypress canoe as a freight carrier was not confined to the rivers and landlocked arms of the ocean, but it ventured upon the open sea, and carried pork and other products from Albemarle Sound to Chesapeake Bay by way of the ocean passage. An adventurous canoeman made a decked cypress dugout and applied to the customs officer for clearance papers for it to sail for the Barbados, but the officer refused to issue the papers, declaring that the request proved the applicant's insanity. Record exists of a cypress canoe 30 feet long, 5 wide, and with a carrying capacity of 13,000 pounds.

Builders of sailboats and small ships in the South drew liberally upon cypress for planking, decking, masts, and other parts of the vessel.

It was early manufactured into certain kinds of cooperage, and was shipped to the West Indies for use by molasses and sugar manufacturers. Cypress seems to have been one of the most important of the southern export woods very early in the commercial history of that region, though it was later replaced by white pine in some parts of the West Indies trade. A century ago the export of cypress shingles to the West Indies exceeded 100,000,000 a year. They were 22

[1] "History of Carolina"—John Lawson.

or 44 inches long, and from 3 to 6 inches wide. In 1808 the price in the West Indies for the large size was from $8 to $10 a thousand, and at the shipping ports about half that.

Early builders in the South preferred cypress for door and window frames, sash, and panels. Some of the old brick plantation houses are so finished. Cabinetmakers selected it in that region for the inside wood of mahogany furniture. Some of the historic church doors in the South are of this wood.

Cypress knees, which are peculiar and characteristic protuberances rising from the roots to the surface of the water where the trees grow, were once much valued by negroes for beehives. The large knees are hollow and they served rustic apiarists well. The negroes made a salve of the resin obtained from the bark and cones of this tree, and used it as one of their household remedies.

EXTERIOR AND INTERIOR FINISH.

Cypress is put to almost every use as an interior trim for houses. It may be finished in natural color or stained. The wood contains little resin, and thus affords a good surface for paint, which it holds well. It is much used for door frames, window frames, transoms, ceiling, wainscoting, panels, doors, sash, balusters, inside blinds, brackets, newel posts, grilles, mantels, and to some extent for flooring. It is a popular wood for kitchens, where it is subjected to dampness and heat. It shrinks, swells, or warps but little, and is used for drainboards, sinks, kitchen and pantry tables, cupboards, and kitchen cabinets. For the same reason it is used for breadboards and wooden implements about the pantry, ironing boards, and clothes driers.

For the parts of houses exposed to the weather it serves equally well. As siding it practically wears out before it decays. When made into porch and portico columns it retains its shape, holds paint, and has sufficient strength to sustain necessary loads. It is placed as cornice, gutters, outside blinds, pilasters, and railing, and is much used for porch floors and steps.

COOPERAGE.

Cypress can not be substituted for white oak for the most exacting kinds of tight cooperage, but aside from that it enters into practically all kinds. The properties which fit it for such wide use are the freedom of the wood from knots and other defects which might cause leakage; the freedom from stains or other chemicals by which the contents of vessels would be injured; and the long period which the wood may be expected to last. To this might be added handsome appearance, which frequently has much to do with popularizing a wood.

Tanks of cypress are made to contain the following materials: Acids, beer, cider, dyes, kraut, oil, pickles, vinegar, water, wine, and whisky. Some typewriter manufacturers have reported it to be superior to other woods for holding acid solutions for nickel and copper plating. Various kinds of water tanks are made—swimming, thrasher, windmill, sprinkling, and for railroad water stations.

Vats require the same kind of material as tanks, but there are generally distinguishing features in form or use. Cypress is manufactured into brewery vats, vats for creameries, bakeries, dye works, distilleries, and soap and starch factories. Users of cypress for brewery vats believe that its durability for this purpose is at times as much as 50 years.

Barrels, tubs, and small vessels made of staves are more directly related to cooperage, and for the manufacture of such commodities cypress has a wide use. Among vessels of that kind are those for lard, molasses, oil, sugar, wine, butter, candy, oleo, tobacco (tubs), vinegar, apple butter, jelly, fish, washtubs and washing machines for laundries and private families, and many kinds of pails and buckets, keelers, noggins, kits, and piggins. It is used rather extensively for barrels or troughs in which to salt and store meat on farms. It is said that New Orleans contains 90,000 cypress water tanks.

FARM LUMBER.

Much cypress lumber is employed in the construction of silos for storing green feed. The farmer puts the wood to many uses, in all of which it gives good service. Its lasting properties fit it well for curbs, when material is needed that resists decay. Watering troughs for farm stock and feed troughs for sheds and barns are made of it; likewise troughs or flumes for conveying water from wells or springs. Resistance to decay fits it for stable floors and timbers near the ground, as well as for fences, gates, and especially for fence posts and telephone poles. It is one of the best available woods for picket fences, because it shows paint well and holds it for many years, but lasts a long time without it. It has been widely used for this purpose not only in the South, where cypress grows, but in regions remote from its range.

One of the widest uses of cypress is in greenhouse construction. It is preeminently fitted for that trying place, where it is called upon to resist dampness, excessive heat, and all the elements that hasten decay. It is said that no other lumber approaches cypress in the quantity used for green and hot houses. It is manufactured into sash, frames, benches, boxes, and practically all else that the builder needs. It has replaced white pine to a large degree, because it is

MISCELLANEOUS USES.

In some southern cities heavy cypress planks are used for street curbing. Agricultural implement and machinery manufacturers make seed boxes of it, wagon makers employ it for beds, and carriage builders work it into panels for fine bodies. Automobile makers put it to similar use. Its slight tendency to warp has caused its employment by builders of incubators. Car shops use it for freight-car siding, piano manufacturers make shipping boxes of it, and it is a material both for coffins and the boxes in which coffins are shipped. Skiffs, steamers, and yachts are occasionally finished in cypress, and many builders of gasoline launches are said to be using cypress exclusively for hull planking. It also makes handsome church pews and benches. Telephone boxes and switchboards of cypress are coming into use, and spools for some purposes are turned from the wood. Apiarists employ it for beehives; fishermen for seine floats; furniture makers for stools, tables, and curtain poles; molders and machinists use it for patterns; merchants for shelving and counter tops; railroads for shims; and carpenters for tool boxes.

Cypress has been substituted for white oak for wine barrels. It is claimed for it that the wood imparts no color or taste to the wine, and that it is sufficiently dense to prevent leakage, and strong enough to stand rough usage. The same property—freedom from taste—is claimed for it by pump makers, who recommend it for that reason.

PECKY CYPRESS.

It has been estimated that one-third of the cypress in the United States is diseased with a fungus popularly known as pecky, peggy, botty, or some similar name. The disease resembles that which affects the incense cedar of the Pacific coast, and, like that, is supposed to be caused by a species of Daedalea. The fungus enters the living tree through broken branches, dead tops, or decaying knots, and excavates holes in the wood from a quarter of an inch to 1 inch wide and often several inches long. These holes are partially filled with brown powder, a deposit or product of the fungus. Though great numbers of such holes exist, and the trunks are perforated by them, the trees are seldom so weakened as to be broken by the wind. When affected trees are felled, the disease quits working on the prostrate trunks.

The effect of the disease is not entirely injurious, since it is believed to act as a preservative upon the wood which remains and to hinder decay. It is a common saying, though perhaps not an entirely true one, that "pecky cypress never rots." The fact seems to be undisputed that it lasts at least as long as unaffected wood. It is not, however, as strong, because of the perforations, nor is it as

handsome. The use of pecky wood is restricted to places where weakness and unattractive appearance are not objectionable. Large numbers of pecky railroad ties are laid yearly, and give good results. Millions of feet of such lumber are built into sidewalks and platforms in southern towns and cities. That the disease has been a long time preying upon cypress timber is apparent from an examination of cypress logs from swamps near New Orleans, dug from alluvial deposits many feet below the present level of the Gulf of Mexico. Some of that prehistoric timber is pecky, though it has been buried during a period which some estimate at no less than 30,000 years.

Immense quantities of pecky cypress are made into fence posts, which are used by railroads of the region to fence their tracks. The diseased wood is employed also for bridge floors, foundation timbers, and for culverts, boxes, walks, benches, and partitions in greenhouses, and for barn and shed lumber.

SEQUOIAS.

But two species of sequoias grow in the United States, the redwood (*Sequoia sempervirens*) and the bigtree (*Sequoia washingtoniana*). Both are confined to the Pacific coast, largely in California.

REDWOOD.

(*Sequoia sempervirens.*)

PHYSICAL PROPERTIES.

Dry weight of wood.—26.2 pounds per cubic foot. (Sargent.)

Specific gravity.—0.42. (Sargent.)

Ash.—0.14 per cent of dry weight of wood. (Sargent.)

Fuel value.—57 per cent that of white oak. (Sargent.)

Breaking strength (modulus of rupture).—8,000 pounds per square inch, on pieces 2 by 2 by 30 inches at moisture per cent of 15.7. (Forest Service.)

Factor of stiffness (modulus of elasticity).—1,140,000 pounds per square inch, on pieces 2 by 2 by 30 inches at moisture per cent of 15.7. (Forest Service.)

Character and qualities.—Light, soft, moderately strong, brittle, grain fine, even, straight, sometimes curly; annual rings wide in the young timber, summerwood thin, dark colored, hard, conspicuous; medullary rays numerous, very obscure; color light to dark red, the thin sapwood nearly white; splits and works easily and polishes well; very durable in contact with the soil.

Growth.—Height 180 to 280 feet, occasionally over 300; diameter 3 to 10 feet, sometimes 15.

SUPPLY.

The redwood belt extends in a strip 500 miles long from southern Oregon to central California. The strip is narrow, ranging in width from 10 to 30 miles. The commercial range has been estimated to cover 3,000 square miles, but the dense logging woods cover a much smaller area than that. The estimates of the merchantable stand vary. In 1880 the Federal census placed it at 25,825,000,000 feet. More than 20 years later, upon fuller information, private estimates doubled that amount, notwithstanding much cutting had been going on for years. The heaviest stand is near the center of the redwood region, in Humboldt County, Cal., though very dense forests exist both north and south of that point. It is not unusual for 50,000 feet to be cut from a single acre, and often three times that. Single trees of enormous contents have been reported, and it is probable that no other timber in this country can show larger yields per acre.

Mature trees attain an age of from 500 to 800 years. The oldest reported was 1,373 years, so that redwood does not attain to the great age of the bigtree of the Sierra Nevada Mountains. Redwood trunks 20 feet in diameter, with heights of 300 feet or more, have been measured, but the average is much under that, ranging between 6 and 10 feet. When a tree passes the age of 500 years it is liable to die at the top.

Redwood is one of the few softwoods that reproduces bountifully from sprouts. Few trees surpass it in that particular, and the vigor of the sprout growth is remarkable. A large portion of the forest is renewed in that way, and the largest trees retain their ability to send up shoots from the stumps.

EARLY USES.

The splendid redwood was inviting to the early settlers of the region, and they put to use as much of it as they needed. The Spaniards cut sparingly, because they wanted little. They were moderate users of lumber, and for their more pretentious buildings preferred adobe or unburned bricks. They found places for a few heavy beams in their churches and mission buildings, but the majority of these structures were in central and southern California outside the redwood belt, and very little redwood found place. The Russian settlers cut considerably more, but their total cuttings were not sufficiently extensive to make an impression upon the hundreds of square miles of that timber near the California and Oregon coasts.[1]

[1] Documentary evidence of the Russians' activity in cutting redwood is not abundant, but numerous sawpits and stumps evidently cut long ago about Fort Ross and Bodega Bay are said to date from the days when the Muscovites in California manufactured redwood lumber with whipsaws.—"Souvenir Humboldt County," California, p. 3.

Settlements of Americans were planted very rapidly after the discovery of gold, and sawmills in the redwood region put in their appearance about 1850. Lumber was cut for houses, barns, fences, and other farm uses, and a small amount of it found its way to the mines, where it was made into sluice boxes, rockers, sheds, and other mining appliances and appurtenances. But the principal mining fields were not near the redwood forests, and the use of the wood by the placer miners was the exception rather than the rule. In some instances boats were made of it, but it was not esteemed for that purpose as highly as Port Orford cedar, which was abundant about Coos Bay in southwestern Oregon. The chief demand for redwood during the early years was as ranch material. The earliest operations by sawmills were south of San Francisco and immediately north of it. It is said that the first cargo of redwood shipped from the Humboldt Bay region was in 1855, though fir and pine were shipped from there earlier. The cargo amounted to 200,000 feet, and went to San Francisco. The earliest operators picked small redwood trees because their primitive mills could not manufacture those of large size. During the Civil War circular saws began to replace the muley saws of the pioneers, and large timber could be handled.

A redwood picket fence at Santa Cruz, Cal., was said to have remained sound 61 years, and in the vicinity of old Russian settlements fence posts are shown in fairly good condition which it is claimed were placed there almost a century ago. That is proof not only of the lasting property of the wood, but also indicates that it was a fence material at an early date. Pioneers put it to use also for poles, grapevine stakes, wharf piles, piers, and supports for bridges, and well curbs. Though the best of the wood resists decay many years on land or in fresh water, it offers little resistance in salt water when attacked by the teredo or other marine borers. The tannin or other acid which the wood contains is credited with rendering it immune from ravages of land insects and fungus, but salt water apparently leaches the substance out in a short time and leaves the wood defenseless. For that reason piles, wharves, cribs, piers, and sea walls built of redwood in early times have not survived in salt water as well as in fresh.

CROSSTIES AND RAILROAD CONSTRUCTION.

In 1902 the Southern Pacific Railroad had in its tracks west of El Paso 12,000,000 redwood ties. That was twice as many as the ties of all other woods combined. Where the traffic is moderate, and where plates are used between the rails and the wood, these ties last 8 to 10 years. If plates are not used the iron rails cut them rapidly. In

most cases a redwood tie wears out before decay renders it useless. Where traffic is light, as on side tracks and switches, the wood gives service two or three times as long as in main lines. Instances have been cited where redwood ties in California were in daily use for 25 or 30 years, but in those cases mechanical wear was small.

The spike-holding properties of redwood are only fair. Softwoods are generally inferior to hardwoods in that respect, and redwood is in the class with average softwoods. The ties are not only extensively used in California and west of the Rocky Mountains, but they are found in considerable numbers in the railroads of Mexico, Peru, Chile, and even in India. One of the chief properties recommending this timber in some foreign countries is its immunity from attack by ants. The coloring substance in the wood is supposed to be the cause of it, and this timber is often, perhaps always, untouched where other timbers may be devoured. The advance in redwood prices in recent years has excluded it from some regions as a tie material.[1]

Railroads employ redwood for many purposes other than ties. It is an excellent culvert timber, because of its resistance to decay. For the same reason it goes into trestles and bridges in positions where strength is not the chief essential. In sheds, warehouses, and buildings of various kinds it is often selected for the foundation material, sills, sleepers, and pieces near the ground. It is used for car roofs, siding, and interiors. The characteristic which fits it specially for these purposes is its small tendency to shrink or swell. This is important in freight-car material, which is liable to pass in a few days from dry summer heat to cold mountain rains or snows, or into fogs, and back again into dry airs. Redwood stands that test in a way highly satisfactory. It holds paint well, which lessens repair bills. Redwood in freight cars has given 20 years of service, a record that will compare well with that of any other wood.

TANKS AND FLUMES.

The industries of the Pacific coast, and in a lesser degree of the whole country, owe much to the good qualities of redwood as a material for tanks, vats, flumes, conduits, and other structures of that class. Railroad water stations in California, Arizona, and Nevada are well equipped with tanks of this wood. They are frequently a part of municipal waterworks. Eureka, Cal., some years ago built a tank 30 feet high, 54 feet in diameter, and with a capacity of about

[1] Twenty years or more ago it was not unusual in central California, near the lines of the Southern Pacific Railroad, to find numerous fields and corrals inclosed by fences with redwood posts which had served as railroad ties until too badly worn for that purpose. When the railroad removed them from the track the vineyardists and stock men hauled them away, and by splitting them made two posts from a tie and got many years of service from them.

584,000 gallons, and later added another of equal capacity. When redwood is first used for holding or conducting water the fluid is stained by the coloring matter leached from the wood, and the same result is seen when water flows from a new redwood roof. In a short time, however, the water clears and no unpleasant results follow.

The wine makers of California equip their cellars with redwood tanks for storage purposes. For this class of heavy cooperage it is one of the best obtainable materials. The density of the wood is sufficient to prevent leakage; the grain is straight, making it easy to work; it gives long service; and is not liable to be attacked by boring insects which sometimes riddle pine tanks. Tanners' vats of redwood last a long time, and the wood resists the action of tanning solutions. Redwood vats also meet the trying demands in cyanide plants where ores are separated.

Some of the finest, largest, and best-built wooden water pipes and conduits are of redwood. It meets requirements so well and in so many ways that large use of it is made hundreds and even thousands of miles from the source of supply. The staves are fitted and joined so accurately that leakage is little more than from iron, and it is claimed that the wood is so much smoother that a given pipe will carry more water than one of metal. This is particularly true after the two have been some years in use. The wood grows smoother by wear and the iron rougher by corrosion and accretions. Pipes from 8 inches to 9 or 10 feet in diameter are in use, and single pipes have been built 20 miles long. Redwood pipes and flumes of this kind have been constructed as parts of municipal water plants or of manufacturing concerns or mines in all portions of the United States. The staves are generally shipped ready manufactured, though some fitting is done on the ground. The pipes are bound with iron hoops. It is possible to carry such flumes across ravines or trestles, or under the ground, and if necessary they can rise above the level or sink below it like a siphon.

Brewers coat their redwood tanks with shellac on the inside to prevent direct contact with the wood. Such receptacles are widely used, not on the Pacific coast alone, but in Milwaukee, Chicago, Cincinnati, and other eastern and central cities.

Aqueducts and flumes in connection with irrigation canals are frequently of redwood. In that capacity redwood has figured perhaps more largely than any other timber in the development of irrigation in California. It has given much satisfaction in the construction of large outfall sewers, where resistance to decay is of much importance. Redwood water pipes, built of staves and banded with metal hoops, are used in many parts of the country.

Redwood gutters and eave troughs for houses are widely used, not only in California. but in distant regions.

HOUSE CONSTRUCTION.

Redwood has long had the reputation of being one of the slowest woods to burn, and for that reason one of the safest materials for wooden houses. It does not kindle in a blaze quickly, and so absorbent is the wood that it takes in water almost immediately, so that a redwood house on fire may be saved when a pine building in the same situation could not be. It is not denied that redwood houses will burn, but it is asserted that they are less liable to burn than buildings of most other woods.

Many California towns were built largely of redwood. San Francisco, as it existed before the fire, was said to be three-fourths shingled and sided with it. In many of the towns and villages near the redwood belt its lumber exceeds any other in quantity used, and perhaps in some instances it exceeds all others combined. One of the largest demands upon it is for shingles, in some years exceeding 700,000,000. Vessels sailing around the Horn carried them to Boston and New York at a time when white pine was plentiful in the East and was in direct competition with redwood as shingles. A Boston building with a redwood roof was still well protected against the weather after 31 years of use. In 1907, of all the shingles reported by species, those of redwood averaged the lowest in price at the point of manufacture, being a fraction over $2 a thousand. It has been claimed for redwood shingles, as for railroad ties, that they wear out before they rot. In some cases this appears to be true. The roof on the old quarters of Gen. Grant at Fort Humboldt, Eureka, Cal., has been cited as an instance. When first occupied by Gen. Grant in 1853 the roof was doing service, and the shingles remained sound more than 40 years afterwards, and would probably have held their place much longer had not the nails that held them rusted off. Many were sent to the World's Fair at Chicago for exhibition. Decay had not marred them, but the weather, assisted by wind-driven sand from the seashore, had worn some of them very thin where directly exposed. Redwood door and window frames in the old fort buildings were remarkably well preserved after nearly half a century of exposure to weather.

A large part of the nearly half billion feet of redwood lumber sawed annually is for house construction, and four-fifths of it finds buyers in California. More than 30,000,000 feet was used in this country outside of California in 1907. The lumber enters into practically every part of the house. Siding takes a large part, and porch columns, cornice, sills, rafters, joists, and studding are in almost universal use within convenient distance of redwood mills, but many persons consider the softness of the wood an objection to its use for

floors. The extensive employment of the wood in many parts of the world is shown by amount and destination of exports. The figures for 1908 show exports as follows: Australia and oriental ports, 23,829,613 feet; South America, 16,875,046; Mexico and Central America, 9,243,091; Europe and Africa, 4,599,215; Hawaii, 4,067,446; total, 58,614,411 feet.

INTERIOR FINISH.

As in house construction, so in interior finish, redwood meets almost every use and requirement. Floors and ceilings are made of it, and wainscoting, panels, moldings, chair boards, brackets, shelves, railing, stair work, spindles, balustrades, and mantels. Formerly such work was often painted, and the grain of the wood was concealed, but the practice is now less common since the natural beauty of the wood is better appreciated. Its colors are rich and varied, and the finisher who understands the art of bringing out their best qualities can please almost any taste. It is a beautiful wood for carving, and is often so employed. The wood of all redwood trees is not of the same color, nor are different parts of the same tree alike. The soil and situation where the tree grows have much to do with it. Shades range from light cherry to deep mahogany. Where the soil is light the wood resembles Spanish cedar. Some grains are so straight that boards may be split 2 inches thick, 12 inches wide, and 10 or 12 feet long.[1] In other cases the texture is so complicated and involved that all semblance to orderly wood is lost. Such wide extremes in grain and color give the carpenter and finisher their opportunity to make combinations to harmonize with nearly any kind of surroundings. Perfect boards of such width and length may be had that panels, shelves, and counter tops of nearly any desired size may be made from a single piece. A panel of that kind has an added value because the wood warps practically not at all, shrinks little, and disfiguration from swelling need not be feared. If it is deemed desirable to darken the natural color of the wood, it can be done with oils. By well-known methods of treatment imitation of rosewood and mahogany may be produced.

The making of redwood doors has been an important business. They are handsome, light, strong, and hold their shape well under changes of climate. Swelling and shrinkage, which give much trouble with doors of various other woods, are reduced to a minimum with redwood.

[1] There are buildings in the redwood districts constructed of split boards, and so evenly is the splitting sometimes done that a rather close examination is necessary to discover that the lumber is not the product of a sawmill. Miles of roads through the redwoods are corduroyed with split planks of this wood.

FURNITURE.

A small quantity of redwood furniture has been on the market since the wood first came into use, but in recent years the demand has greatly increased. Two distinct patterns of this furniture are made—that which is without figure in the wood, but with pieces and panels broad, ample, and in appearance homogeneous; and that made of figured wood. Formerly the grain of redwood was not often considered by furniture makers, but it has been learned that most pleasing designs may be cut from wavy grain, curly stump-wood and roots, and from the large burls. Pieces with abnormal grain are cut of such size that one slice may be sufficient for a table top or for a massive panel in a bedstead or cabinet. Such wood is worked in the same way as figured walnut and mahogany, though perhaps it is not cut as often in veneers. Exquisite redwood veneers, however, are frequently cut for use by the furniture maker or house finisher.

Redwood burls of exquisite figure and 6 or 8 feet across are sometimes obtained. An armchair has been cut in one piece from a burl, and tables and other articles of furniture when made of it may command prices equal to Circassian walnut or the best English oak. Numerous small articles, such as napkin rings, pin trays, collar boxes, match safes, cane crooks, and many others, are made from redwood burls.

A supply of stumps that will scarcely be exhausted during the present generation is found in the regions where this timber has been cut and the land has not been cleared for agriculture. Many of the stumps have figured grain which is valuable in fine furniture making. The redwood furniture on the market includes nearly all kinds and styles, but the leading articles are desks, bookcases, bedsteads, settees, chairs, tables, bureaus, chiffoniers, and cabinets.

MISCELLANEOUS USES.

Redwood shakes have been a merchantable commodity for 60 years in California, and have sometimes been shipped elsewhere. They are usually split from straight, perfect wood and are used for covering buildings and as siding for barns and sheds. In size they are smaller, but in use very similar to the clapboards formerly employed in the Eastern States as roofing for log cabins and other buildings. The split shake is a wasteful product, and its diminishing use is not a matter for regret. In recent years, however, there has been a tendency to saw shakes instead of splitting them. Sawed shakes were not unknown 20 years ago, but they were not much used. Some of the shingle mills have added shake saws and find them profitable. The product can be made from any wood that will make shingles and no

account is taken of cross grain. The waste compared with that resulting when shakes are split is reduced to a minimum.

Redwood has been tested to some extent for paving blocks. After 15 years' service pavement of this wood has been found in fairly good condition. In this, as in many other of its uses, its resistance to decay is among its chief recommendations. It has others, however, for its softness makes it easy under horses' feet and it is nearly noiseless.

Pattern makers draw upon redwood for supplies. It has not the exclusive field even among California woods, sugar pine being a competitor, while in the East it competes with yellow poplar, basswood, and white pine. Some large manufacturers prefer redwood for this purpose, and it seems likely to gain rather than lose as a pattern material in foundries, machine shops, shipyards, and other factories and shops.

It goes to New York and other eastern cities for tobacco boxes. Comparatively few woods meet the exacting requirements insisted upon, which is that they must not impart taste or odor to the tobacco. Formerly sycamore was almost the exclusive wood for these boxes, but others have come in, notably tupelo, and now the California redwood has successfully met the requirements.

Cigar-box makers are not so choice in material as are the manufacturers of boxes for plug tobacco. Appearance has much to do with their choice, and redwood is meeting the Pacific coast's cigar-box makers' demands.

Redwood box lumber competes with sugar pine and other coast softwoods for fruit boxes. Its dark color is sometimes objected to because it increases the difficulty of doing good stenciling. When both redwood and white fir are convenient and available, many fruit packers prefer the latter for boxes.

Musical-instrument makers do not appear to have drawn heavily upon redwood, probably because the manufacture of musical instruments is not a highly developed industry on the Pacific coast. It is listed, however, as a piano wood by Massachusetts manufacturers.

A small quantity of this timber goes to the makers of wagons and carriages and is worked into tops, chiefly light bodies, seats, dashboards, or in panels for business vehicles, such as bread, butcher, and laundry wagons. The liability of the thin boards to split under a blow tends to limit their use, but that there is demand for them is evident from the fact that they are used in shops thousands of miles from the native timber belt.

Coffins of this wood are largely used on the Pacific coast, where they compete with those of the native cedars.

Before slate and composition blackboards for schools had largely taken the place of all other kinds redwood held a sort of monopoly

for extra widths. One piece was enough for an entire board, and splicing and joining were not necessary. It was little trouble to procure planks 4 or 5 feet wide and as long as necessary. This timber has been sawed in planks 10 feet wide.

Shop signs painted on redwood are occasionally seen in England, and the wood is also used for lining cabinets, boxes, compartments, and drawers. Its use has been reported for lead pencils and champagne corks in Germany. The pearl divers of the Society Islands make of three redwood planks boats, with outriggers, which navigate the lagoons and shoals during the diving season.

BY-PRODUCTS.

Tests of paper making from redwood indicate that the enormous waste about the mills and logging operations might be turned to account. The wood is cooked with caustic soda, and the black liquors from the digesters carry away the coloring matter from the pulp, which is then ready for paper making. The article thus made resembles, it is said, the grade known as butcher's paper rather than print stock.

The black liquor from the digesters is concentrated to the consistency of asphalt, then roasted and reduced to gas, similar to natural or coal gas. It may be used for illumination, for operating gas engines, or for fuel. One ton of redwood scrap from the mill is said to yield 500 pounds of pulp and 10,000 cubic feet of gas. This gas, if used in an engine, would probably furnish enough power to run the mill. It was estimated in 1907 that the waste from the redwood mills in the region of Humboldt Bay amounted to 560 tons weekly.

Redwood bark is used in a small way for many purposes—some useful, others merely ornamental. Novelty stores and souvenir stands along routes of travel in the redwood region, as well as in San Francisco and other Pacific coast cities, exhibit many bark commodities for sale, including pincushions, penwipers, table mats, lamp mats, doilies, moisture-proof match safes, seat mats, bathroom mats, and silk-hat brushes. The bark is also used for fishing floats, temporary cork, life-buoy filling, cork jackets, cold-storage insulation, heat insulation, house sheathing, bicycle grips, mattress fillings, cork carpet substitutes, and sound-deadening insulation. In small towns in the redwood region it is not unusual to lay sidewalks of wide pieces of redwood bark. Such walks are dry and moderately lasting.

WASTE.

The enormous size of redwood timber makes its lumbering wasteful. Sometimes very large trees crush so completely when they strike the ground that little saw timber can be saved. The weights of the

very large trees run from 500 to 1,000 tons. Much experience and skill are needed in cutting them down. A mistake of a few yards in the direction in which they are thrown may entail an unnecessary loss of $100 or more. The débris that strews the ground when one of the 300-foot giants falls is "shoulder deep." However, more careful methods prevail than formerly. It is customary to clear a space and prepare a bed for the tree to fall in, and experienced choppers usually are able to lay the trunk where they want it. It is still the custom of loggers to peel the logs and then burn away the bark and other débris to facilitate getting them out. Often the logs are badly burned. The loss from this proceeding is very large, as much of the standing timber within reach of the fire is killed and the humus destroyed.

Many other wastes were once common, and some of them still are, but the tendency is toward better methods. Crooked and defective logs were abandoned, though they might contain thousands of feet of good lumber. Enough small timber was frequently cut for skid roads and in clearing away to stock a sawmill. In floating down rivers to the mills many logs sank and were lost, and others went to the sea.

Other items, enormous in the aggregate, figure in redwood waste and loss. Large logs are often split with powder to make them convenient to handle. This damages some of the best wood. A large percentage of the trees are wind-shaken, and pin rot affects many. The defective wood and often good wood near it have been thrown away. Increasing demand, however, has caused more attention to be shown to the waste heap, and what will make lath, shingles, shakes, and ties is manufactured into those commodities and others of like kind.

BIGTREE.

(*Sequoia washingtoniana.*)

PHYSICAL PROPERTIES.

Dry weight of wood.—18.2 pounds per cubic foot. (Sargent.)

Specific gravity.—0.29. (Sargent.)

Ash.—0.5 per cent of dry weight of wood. (Sargent.)

Fuel value.—38 per cent that of white oak. (Sargent.)

Breaking strength (modulus of rupture).—6,400 pounds per square inch, or 49 per cent that of white oak. (Sargent.)

Factor of stiffness (modulus of elasticity).—650,000 pounds per square inch, or 31 per cent that of white oak. (Sargent.)

Character and qualities.—Very light, soft, weak, brittle, grain coarse, even, and straight; annual rings generally wide but variable in both young and old trees; summerwood thin, dark-colored, con-

spicuous; medullary rays numerous, thin; color bright clear red, turning much darker with exposure, the thin sapwood white; very easily split and worked; remarkably durable in contact with the soil.

Growth.—This is the largest tree in America, the weight of the largest being estimated to exceed 1,000 tons. Mature trees attain heights of from 200 to 350 feet and diameters of more than 25 feet. Including the great swelled bases, specimens have been measured nearly or quite 40 feet in diameter.

SUPPLY.

The bigtree is of sentimental rather than of commercial importance. As far as actual use is concerned, nearly every timber tree in the United States is superior to it. Even the sycamore, buckeye, tamarack, cottonwood, larch, and elm supply more lumber, and dogwood and persimmon are more useful. Though the largest tree in America, the actual quantity of wood which this species is capable of furnishing is small. This is due to the exceedingly restricted area where it grows. It may almost be said that the number of individual trees is known. While this is not strictly true, it is more nearly true of it than of any other well-known tree. The stand is restricted to a few isolated groves on the western face of the Sierra Nevadas in California, lying at altitudes from 5,000 to 8,000 feet. In most instances these groves are separated by deep canyons, suggesting the probability that the sequoias once formed a continuous forest along the face of the mountain, and that glaciers pushing down the canyons cut the forest into many parts. Though the ice subsequently retreated, the big trees were never able to reunite their fragmentary groves. There is unquestionable geological evidence that the range of the species was once widely extended.

Some persons erroneously suppose that the sequoias are all old and that no young trees are coming on. This is incorrect in most cases. Reproduction is vigorous where conditions are favorable, and if future supply is less than the present it will not be due to barrenness of trees now living. Where protected from fire, seedlings spring up and if given a chance will hold their place. It is not difficult to plant these trees and make them grow, though it is not probable that planted sequoias will ever exert any influence upon the timber supply. No matter how patient the forester may be, he can not wait a thousand years for his trees to come into market.

When the Government was considering the purchase of the north and south Calaveras groves the sequoias within the proposed boundaries were counted, and those of merchantable size were measured. Trees under 3 feet in diameter were classed as unmerchantable, and were counted but not measured. All seedlings that could be found

were counted, and the total number of all sizes was 3,462. There were 863 merchantable trees listed in six classes, as follows:

Trees containing less than 20,000 feet each	353
Trees containing 20,000 to 40,000 feet each	251
Trees containing 40,000 to 60,000 feet each	112
Trees containing 60,000 to 80,000 feet each	49
Trees containing 80,000 to 100,000 feet each	13
Trees containing 100,000 to 120,000 feet each	2

The 20 largest trees contained an average of 81,386 feet each of merchantable lumber. The average for 862 trees was 27,738 each. The largest tree fell a little short of 120,000 feet, and two exceeded 100,000 feet.

AGE AND SIZE.

There is much disagreement concerning the age and size of some of the largest of the big trees. Different figures as to size, where measurements have been recorded, are due in many instances to different methods of measurement. The tree usually has a greatly enlarged trunk near the ground, and the diameter at 2 feet might exceed by several feet a diameter at 8 or 10 feet. Height measurements ought not and do not show such disagreement where they are carefully made and recorded. One of the largest trees was 25 feet in diameter inside the bark at 6 feet from the ground. One of the tallest trees, measured after it fell, was 365 feet. The tree 25 feet in diameter, mentioned above, was 302 feet high. The bark was removed from its trunk to the height of 30 feet and was exhibited in London half a century ago, but was consumed in the fire which destroyed the Crystal Palace at Kensington.

It might be supposed that many records exist showing the age of big trees that have been felled. Such is not the case, but a few accurate and reliable counts of annual rings have been recorded. In one instance a tree 24 feet in diameter was less than 1,300 years old. Another of similar size was 2,200 years old, according to the count made by John Muir. Another count by him of a tree of similar size showed more than 4,000 rings, but they were so intricately involved that he was unable to satisfy himself that he had counted all of them. It is believed that no tree of this species showing more rings has been placed on authentic record. Claims of greater age have been made, but efforts to substantiate the claims by locating the trees and ascertaining by whom and when the rings were counted have not been successful. Size alone does not prove great age, and no rule of estimate based on so many years for so many inches of diameter can be relied upon. The Forest Service has made accurate measurement and record of every ring of growth in a tree more than 24 feet in diameter, and it is shown that during certain periods of years the

tree grew three or four times as rapidly as during other periods. It is further shown that the times of rapid growth and of slow growth were not dependent upon the size or age of the tree, but occurred at different times during the tree's history, suggesting that successive changes in environment produced changes in the rate of growth, and accounting for the fact that while one tree 24 feet in diameter might be 1,300 years old, another of similar size might be 4,000.

OWNERSHIP.

Some of the finest sequoia groves belong to the United States Government, and are being protected against reckless lumbering and fire, thus giving the younger trees a chance to grow. Other groves are privately owned, and in such cases no sentimental regard protects them against the lumberman's ax and saw, and the trees go to the mills on the same terms as other species growing near them. The cut is far in excess of growth, and when the present stand has been felled the end of private groves will be in sight.

MANUFACTURE AND PRODUCTS.

Lumber cut from the big trees has not generally been put to uses commensurate in dignity with the majesty of the forests from which it comes. Perhaps as much of it has been cut for grapevine stakes as for any other one purpose. It might be assumed that the sequoia's wood merits a place as beams, girders, pillars, and king-posts in solemn churches, enormous halls, and cathedrals where gigantic timbers must support ponderous roofs, balconies, and architraves. But the big tree is put to no such use. It is unfit for such purposes, for the trunks are so vast that long logs cut from them can not be hauled to the mills, while the wood is weak and brittle, and no architect would permit it to go where an excessive load would rest upon it. Beams of long-leaf pine or Douglas fir will sustain burdens which would crush a sequoia beam of similar size. In logging big trees it is frequently necessary to split the logs with powder to reduce pieces to sizes which can be handled. Many fragments result of shape and sizes not suited for lumber. These are worked into stakes for vineyards, and the loss that would otherwise be due to waste is greatly lessened.

Next after vine stakes, probably fence posts require the largest quantity of this wood, which is very durable. The claim has been made for it that it outlasts any other known wood, but similar claims have been put forward for redwood, red cedar, cypress, western red cedar, locust, and other woods, and no one of them has yet established its claim to first place in point of durability. Big tree trunks, with the heartwood sound, have lain in the forests for

ong periods, possibly in some instances for hundreds of years. It s supposed that the coloring matter in the wood has much to do vith preserving it from decay. When sawed or split into fence posts it gives long service, and buyers are anxious to procure it for 'ence material.

Stakes and posts do not take it all, however, nor generally the est of it. It is made into shingles, shakes, siding, frame material, and rough lumber. Some of the best grades are worked into frames for doors and windows, and also into doors, panels, wainscoting, helves, turned articles, and furniture. Small trees that do not need o be sawed or split are cut for electric-line poles. Though the wood of mature timber is remarkably free from knots, small trunks are knotty, because young trees retain their limbs nearly to the ground. After the lower branches die and fall off, the new wood laid on is clear. Sound lumber gives satisfaction when worked into flumes, conduits, and water pipes.

The wood has been employed by lead-pencil makers, and in that ndustry it competes with red cedar. Seven carloads of it were shipped to France in 1905–6, and several carloads were sent later.

WASTE.

The great size of the big trees is chiefly responsible for the unusual waste attending their conversion into lumber. The fall of the mature trunks is so violent that instances have been cited where large trees were so completely demolished that not a stick of saw timber could be cut from them. Heavy loss must occur under the most favorable conditions.

Though it is liable to meet partial destruction when it falls, the tree has means of self-defense and protection while standing which place it on an equal footing with any other tree and superior to most others. Were they not well protected from the ordinary and numerous enemies and dangers which beset and attend forest trees they could not survive 3,000 or 4,000 years, as some of them have done. It has been said of these trees that they have only three foes to fear—lightning, the undermining of their roots by water and erosion, and fire. Lightning sometimes strikes them, but since most of the large trees have stood a thousand years or more without having lightning scars to show, it is evident that they are more remarkable for immunity from, than for injury by, that danger. The undermining of their roots and the consequent settling of the massive trunks toward the injured foundation causes an occasional overthrow, but observation leads to the conclusion that most falls are due to the enormous size and weight of the limbs which grow on the sides where light is most abundant, and which gradually cause the trunk to lean in that direction and finally throw it.

Fire has been the big tree's greatest enemy. Scars on old big-tree trunks record fires that burned 17 centuries ago, and at intervals from that time down to the present. Some of the burns on the trunks were 100 years in healing, yet the vitality of the tree is so great and its stored reserve of food and water so large that it recovers from injuries which would prove instantly fatal to most trees. A trunk stripped of all its bark for nearly 100 feet has been known to survive during several following years. There are trees of other species which, if subjected to such abuse, would wither within 24 hours.

The bark of the big tree sometimes attains a thickness of 2 feet. An ordinary forest fire can not burn through it, and it affords ample protection except where much trash has accumulated about the base of the tree. When an entrance to the wood has once been opened each succeeding fire enlarges it, finally causing much damage to the tree and possibly leading to its fall. The thick bark has a commercial value when manufactured into novelties and articles of use and ornament such as pincushions, penwipers, mats, boxes, frames, trays, and many more. It is not customary, however, to save the bark at the mills when the trunks are converted into lumber, and it is added to the many other wastes.